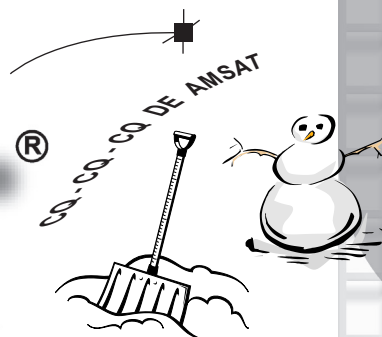


The AMSAT[®] Journal



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Ed Long, WA4SWJ

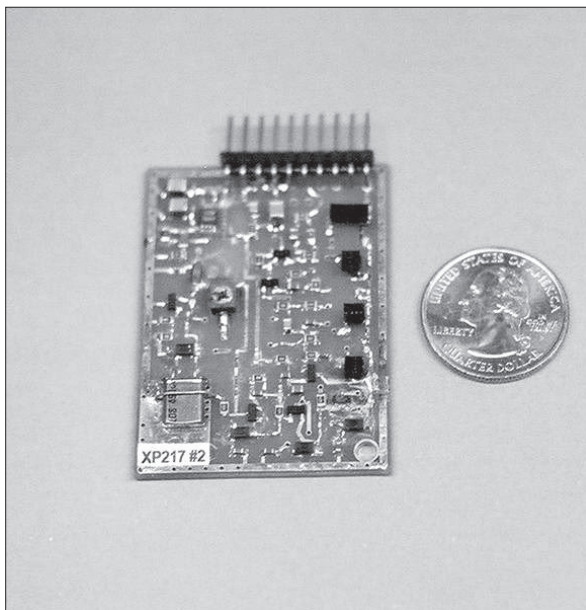
Editorial Staff:
Bill Hook, W3QBC

Volume 29, Number 6

November/December 2006



Completing N2SPI's Cheap and Easy Sat- ellite Anten- nas - Building a Crossboom.



A RADAR detector in orbit? YES!!

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A codicil in your will, naming The Radio Amateur Satellite Corporation as a beneficiary will help insure the continuance of the Amateur Radio Satellite program.

Call the AMSAT-NA office at 301-589-6062 for questions on any or all of these ways you can help build new and exciting satellites.

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AMSAT Announcements

To all AMSAT members:

The editor and staff of The AMSAT Journal wish you the happiest of holiday seasons! We hope you had a great 2006 and we're looking forward to bringing you more issues of The AMSAT Journal in 2007.

Martha, WA4SWJ and W3QBC



History Anyone?

Notice that this issue is Volume 29, Number 6 of The AMSAT Journal. Next year, at least according to the way the volumes are numbered, would be 30 years of Journal publication. We know that for all 30 years this publication has not been known as The AMSAT Journal. Does anyone know the history? If so are you interested in writing an article about it? Please contact Ed Long if you are interesting in writing something.

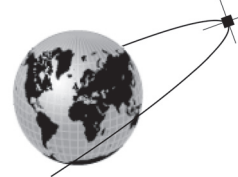
AMSAT's Mission

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow Amateur Radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

AMSAT's Vision

Our Vision is to deploy high earth orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.





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The AMSAT Journal staff is always interested in article submissions. Whenever possible, submissions should be sent via e-mail to journal@amsat.org using plain text or word processor files; photos or figures in TIF, GIF or JPEG formats. AMSAT-NA reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations. The editors of this publication are volunteers giving freely of their talents, time and efforts to produce *The AMSAT Journal*.

AMSAT-NA Signs Agreements to Build Eagle at a UMES Facility

AMSAT-NA has accepted an offer to co-locate its Satellite Integration Lab with the Hawk Institute for Space Sciences (HISS), a division of the Maryland Hawk Corporation, which is a 501(c)(3) non-profit educational organization affiliated with the University of Maryland Eastern Shore (UMES). The HISS facilities, currently under construction, are in the Mid-Atlantic Institute for Space and Technology (MIST) building in Pocomoke, Maryland, on the Maryland Eastern Shore of the Chesapeake Bay. Maryland Hawk is a member of MIST. HISS is a division/unit of Maryland Hawk. Pocomoke is about a 3-hour drive southeast of the Baltimore-Washington International airport.

AMSAT-NA has been actively searching for a suitable location for the past two years as AMSAT's most recent lab at the municipal airport in Orlando, Florida was condemned due to damage by Hurricane Charley on August 13, 2004. With the unanimous approval of the AMSAT-NA Board of Directors, AMSAT-NA has executed two Memoranda of Understanding, one with the University of Maryland Eastern Shore and the other with Maryland Hawk Corporation, formalizing the relationship. These MOUs give AMSAT-NA essentially no-cost access to the HISS facility in return for sharing its equipment and ideas with HISS. In addition, the agreement with UMES calls for AMSAT-NA to work collaboratively with UMES to identify opportunities to work together on satellite and related technology projects as well as to work with their students and faculty to enhance hands-on studies and dissertation research. The possibility also exists for AMSAT-NA scientists and engineers to receive Adjunct status at the UMES.

AMSAT's VP Engineering, Bob McGwier, N4HY, commented, "I consider these happenings to be a serious beginning of the activities toward a real spacecraft." AMSAT's lead mechanical engineer, Bob Davis, KF4KSS, is also an employee of HISS resulting in AMSAT having a representative on site at all times. Bob Davis was AMSAT's mechanical design expert in the Orlando lab during the AO-40 satellite campaign.

HISS is currently constructing the interior walls for their new 8,000 square foot facility. It is being designed around AMSAT's dual clean room, which was used for AO-40

and is in storage at Florida Space Institute. AMSAT will move the clean room and the parts and equipment currently in storage in the Orlando area to the new lab in the next few months. The facility will also include adequate meeting and office space for visiting AMSAT personnel. The agreement with HISS also provides AMSAT limited access to NASA Wallops Flight Facility with its environmental testing, machine shop, rocket manufacturing and launch facilities.

AMSAT members Bob Davis, KF4KSS, Rick Hambly, W2GPS, Tom Clark, K3IO, Jim Sanford, WB4GCS, and Bob McGwier, N4HY, have worked very hard on this project. AMSAT members are encouraged to volunteer to work in the new lab, come by and visit (call first), and donate to the P3E and Eagle satellite funds.

Moving Day

Between December 24th and January 7th a volunteer AMSAT team will be moving AMSAT's equipment, parts, furniture and clean room from Florida to the new lab in Maryland. The team includes Bob Davis, KF4KSS, Drew Glasbrenner KO4MA, Stan Wood, WA4NFY, and Lou McFadin, W5DID, and others. They will be renting at least two large trucks to carry everything. These volunteers deserve a special thank you for giving up much of their holiday vacation time to help AMSAT.

AMSAT Needs You!

AMSAT needs your support to achieve our goals. Our Eagle satellite project is ramping up, as you can see from the progress on our lab. Please call the office or visit the AMSAT Web store to make your donation to keep us going. All donations of \$120.00 or more qualify for President's Club status.

For information on setting up a hamfest AMSAT booth or giving presentations at local ham clubs contact Martha at the AMSAT office (301) 589-6062 or your AMSAT Field Operations Director, Gould Smith, WA4SXM, at wa4sxm@amsat.org.

73,

Richard M. Hambly, W2GPS
AMSAT President



The XP217 Experimental RADAR Transponder for the RAFT1 CubeSat

Anthony Monteiro, AA2TX, aa2tx@amsat.org
Robert Bruninga, WB4APR, Bruninga@usna.edu

Introduction

"...Now we have another great launch where eight microsat's were placed into orbit, and everyone is scrambling to come up with some Keps that reflect who is who up there. The tracking folks do a great job, but from what I remember from last year's operation was that it will be a while before it is straightened out up there. I'm sure the trackers have no problem finding the large stuff, like the booster stage and shrouding. But when it comes to the microsat, well that's another issue. They're small in size and probably close together right now. First they will have to find them, and then try to figure out who is what. I can recall from last years launch that it took the better part of a MONTH before it was settled..." [1]

The US Air Force Space Surveillance System (AFSSS) RADAR [2] provides critical orbiting object data to NORAD [3], which generates the Keplerian elements needed to track satellites orbiting the earth. The advent of CubeSats, MicroSats, PicoSats and other small satellites launched in clusters, has caused a difficulty in identifying specific satellites in orbit since the number and very small size of these satellites is beyond the ability of the AFSSS RADAR to distinguish them.

The RAFT1 CubeSat project was developed as a response to these issues and was approved by the Department of Defense, Space Experiments Review Board in 2002. This satellite will conduct experimental interactions with the AFSSS RADAR to determine if an active transponder could

assist in tracking and identifying very small satellites. The RAFT1 CubeSat, shown in Figure 2, is a 5-inch cube covered with solar cells and includes antennas for 217 MHz, 146 MHz and 29 MHz. The AFSSS Radar experiment is the primary mission and the satellite carries an Amateur Radio payload as a secondary mission. RAFT1 was developed by midshipmen at the US Naval Academy Satellite Lab under the leadership of AMSAT member, Bob Bruninga, WB4APR, and is scheduled for launch on Space Shuttle Discovery, STS-116, in December 2006.

A block diagram of the satellite can be found in Figure 3. The RADAR experiment,

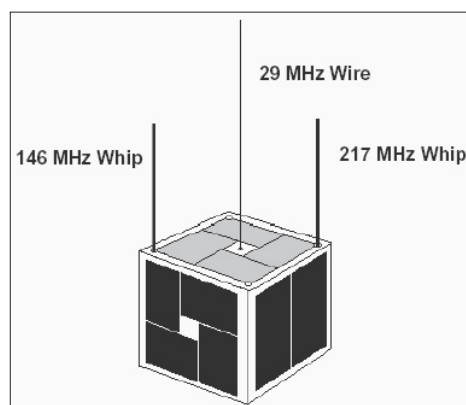


Figure 2: RAFT1 CubeSat.

shown in the dashed lines, includes a direct-conversion receiver and a beacon transmitter operating at 217 MHz. The output of the 217 MHz receiver is fed into an FM downlink transmitter operating on the 2-meter Amateur

Radio band at 146 MHz. This will allow the RADAR signal to be monitored by ham radio ground stations as the satellite passes through the beam. The 217 MHz beacon transmitter provides a signal designed to assist the AFSSS RADAR receivers to positively identify the satellite.

RAFT1 has a VHF FM receiver, also operating in the 2-meter ham band, and it feeds a customized AX.25 Terminal Node Controller (TNC.) This TNC provides the Telemetry, Command and Control functions for the satellite and provides a digital transponder for use in the Amateur Satellite Service. The output of the TNC is fed to the VHF FM transmitter for the downlink. The VHF transmitter and receiver operate on the same frequency using half-duplex mode. The transmitter and receiver share the same whip antenna through a pin-diode based electronic switch.

RAFT1 also includes a PSK-31 receiver operating on 28.12 MHz. The PSK-31 signals are combined with the audio output of the TNC and fed into the VHF FM transmitter. The TNC and PSK-31 transponder can operate simultaneously as they use different parts of the audio spectrum. For more details of the RAFT1 satellite, please see the RAFT Web site [4].

While most of the electronic subsystems needed for the satellite are available off-the-shelf, no current manufacturers provide the equipment needed to interact with the

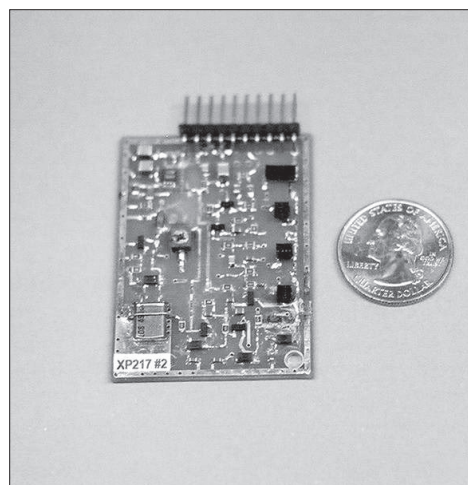


Figure 1: XP217 RADAR transponder with US quarter coin.

RAFT1 Radar Fence Transponder

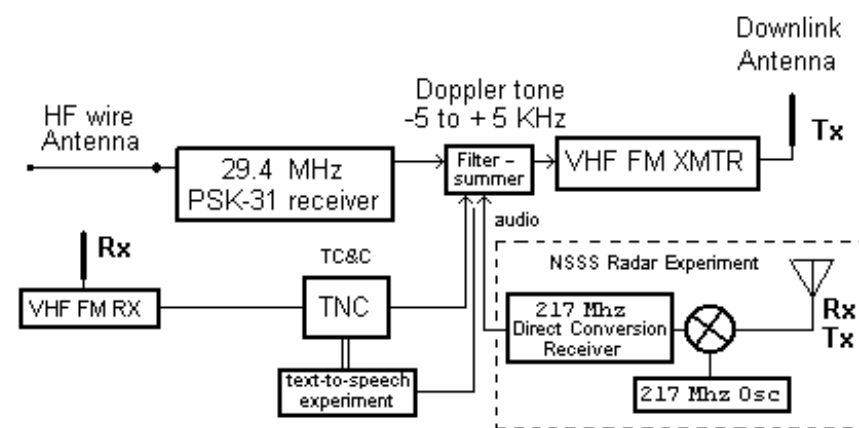


Figure 3: RAFT1 satellite block diagram.



Figure 4: AFSSS transmitting and receiving stations [5].

AFSSS RADAR system. A team of three AMSAT members from the Boston area, Joe Fitzgerald, KM1P, Dave Goncalves, W1EUI, and Tony Monteiro, AA2TX, volunteered to help by designing and building the XP217 RADAR Transponder Unit. Additionally, Tom Kneisel, K4GFG, volunteered to assist in understanding technical aspects of the AFSSS RADAR.

AFSSS RADAR Fence

The Air Force Space Surveillance System (AFSSS) is a network of RADAR transmitting and receiving stations that all operate at around 217 MHz. The transmitting sites generate a continuous-wave fan beam, called the *Fence* that is very narrow in the

North/South direction but extends straight up, from East to West across the entire southern United States. Any object that crosses the *Fence* will generate an echo that will be detected by the receiving stations. The AFSSS includes three transmitting stations and six receiving stations as shown in Figure 4.

The main transmitting station is in Lake Kickapoo, Texas. It consists of a linear array of 2,556 inverted-V antenna elements over a reflector screen, each with its own 300-watt power amplifier. It generates a total effective isotropic radiated power (EIRP) of over 6,000 megawatts. A photo of part of the antenna is shown in Figure 5.



Figure 5: Photo of Lake Kickapoo transmitting antenna [7].

The Lake Kickapoo transmitter operates at 216.980 MHz. The other transmitting sites are lower power but help to fill in the east and west edges of the *Fence*. They are at Gila River, Arizona on 216.970 MHz and at Jordan Lake, Alabama on 216.990 MHz.

The six receiving stations are at San Diego, CA, Elephant Butte, NM, Red River, AR, Silver Lake, MS, Hawkinsville, GA and Tattnell, GA. The AFSSS receiving stations each have an interferometer antenna array and use a variety of signal processing techniques to extract the orbital vectors from the received echo. For more information about the AFSSS RADAR, please see the Web site by Tom Kneisel. [6].

The AFSSS RADAR Experiment

The RADAR transponder on the RAFT1 satellite will provide a receiver and a transmitter on the Lake Kickapoo frequency of 216.980 MHz. The receiver is a direct-conversion type and the recovered audio tone is the difference between the receiver local oscillator and the Doppler-shifted, Lake Kickapoo transmitter frequency as seen at the satellite. When enabled, the receiver audio output will be fed into the 146 MHz VHF FM transmitter so that ground stations can actually listen to the RADAR signal as the satellite flies through the fence.

The transponder transmitter is an unmodulated CW beacon that the RADAR ground stations will be able to easily detect.

Transponder Design Highlights

The XP217 transmitter section provides 4 mW (+6 dBm0) of output power at 216.980 MHz. This is fed into a whip that is tuned to this frequency. An interesting feature of the transponder is that the receiver and transmitter operate simultaneously using the same whip on the same carrier frequency.

When RAFT1 crosses the RADAR fence within range of the Naval Academy at Annapolis, MD, the nominal received signal level is expected to be about -43 dBm0 but may vary within the range of -22 dBm0 to -52 dBm0 depending upon the Faraday rotation and satellite orientation. The received signal will typically be several KHz above or below the carrier due to the Doppler-Shift seen at the satellite. The difference between these signals is converted to audio in the XP217 receiver.

The recovered audio from the XP217 will be relayed by a downlink transmitter operating in the amateur 2-meter band. This transmitter has an output power of 1 watt (+30 dBm0.)

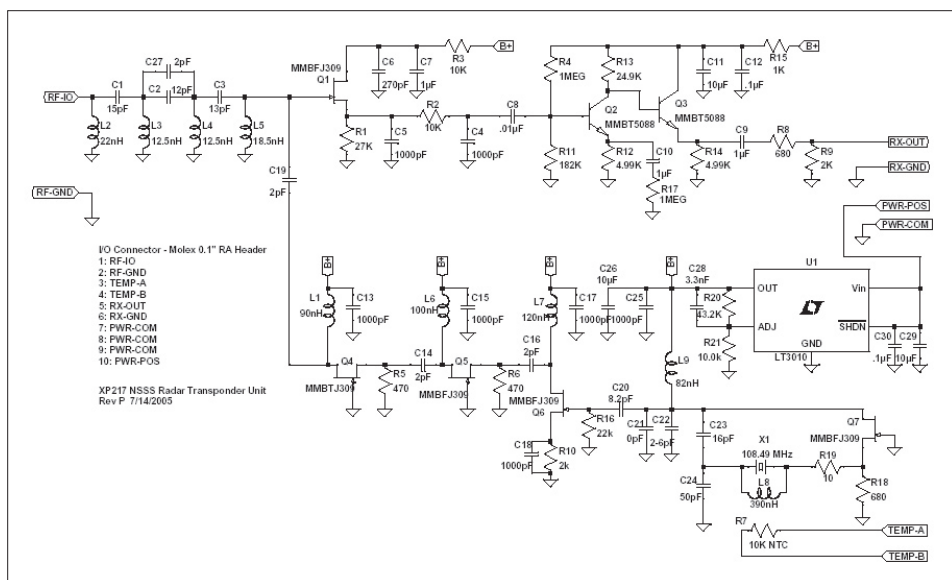


Figure 6: XP217 circuit.

An EZNEC [8] model of the RAFT1 antennas indicated that the downlink signal at 146 MHz would be +30 dB to +50 dB higher at the receiver input than the desired signal. The XP217 receiver includes a high-pass filter to reject this 146 MHz signal.

Since this transponder was specifically designed to fly on very small satellites, it needed to be very small also. The project goal was to make the XP217 about the size of a book of matches.



Figure 7: Dad's assistant, Veronica Monteiro, shows off an XP217 ready to be tested.

Transponder Circuit

The XP217 Transponder circuit schematic is shown in Figure 6.

A voltage regulator circuit using a Linear Technologies LT3010 (U1,) provides +6.8 VDC for the other transponder circuits. The LT3010 is a low-drop-out linear voltage regulator and will maintain regulation with as little as +7 VDC on its input. The entire transponder only draws about 12 mA so the power dissipation is low.

The crystal oscillator consists of Q7, a J309 FET, and uses a 108.49 MHz crystal operating in a fifth-overtone mode. The circuit is a Butler oscillator using the FET in a grounded-gate configuration. Inductor L8 cancels the crystal holder capacitance so that the frequency at the maximum amplitude of the feedback is the same as where the phase is 0-degrees (i.e., the crystal will oscillate at the correct frequency.) Trimmer capacitor C22 is used to fine-tune the oscillator. Inductor L9 resonates with the capacitors at the output to 108.490 MHz.

The crystal oscillator drives the frequency doubler stage consisting of Q6, a J309 FET. The output of this stage is tuned to 216.980 MHz using L7, C16 and the output capacitance of the FET. This forms an L-network and provides an impedance match to the input of the driver stage FET, Q5.

The driver and power output stages consist of J309 FETs Q5 and Q4 respectively.

They increase the level of the local oscillator signal up to about +7 dBm₀. L1 along with C19 and the output capacitance of Q4 form an L-network and match the output impedance of Q4 to the 50-ohm impedance of the RF filter. The RF Filter consisting of capacitors C1, C2, C3, and C27 and inductors L2, L3, L4 and L5 form a high-pass filter and provides significant rejection of the 146 MHz downlink signal but allows the received 217 MHz RADAR signal to

pass through with only around 1 dB loss.

The received RADAR and the local oscillator signals appear at the gate of Q1, another J309 type transistor, which operates as a high-impedance mixer. This transistor is biased nearly to cut-off by the source resistor R1. When the input signal on the gate goes negative, the transistor remains nearly cut-off and there is very little change in the current through the transistor. When the input signal goes positive, the transistor turns on and conducts a current from source to drain creating an output voltage across R1, which follows the envelope of the combined RADAR signal and local oscillator injection. The output signal is low-pass filtered by R2, C4, and C5 to remove the high-frequency components leaving just the recovered audio signal.

The audio output of the mixer is coupled to Q2, a low-noise, 2N5088 type, bipolar transistor that amplifies the received signal. Resistor R17 controls the degree of negative feedback, which sets the overall voltage gain. By setting R17, the gain is adjustable over a range of about 4.5 to 45. Transistor Q2 is directly coupled to Q3, another 2N5088 type transistor, operating as an emitter-follower buffer. The audio output is designed to drive a 1K ohm load. The output voltage divider consisting of R8 and R9 allows the output level to be adjusted to that required by the downlink transmitter.

Construction

To meet the "matchbox" size goal, the XP217 uses all surface mount components. A two-layer printed circuit (PC) board was designed with the bottom layer being primarily a ground plane. The PC board layout was developed using free software from ExpressPCB [9] and ordered through their Web site. The two flight models were constructed by hand-soldering the components to the pc board. This was a significant chore given the tiny size of most of the components!

Testing

The XP217 flight models were subject to an intensive set of functional tests. The tests were performed in the basement lab at the Monteiro residence as can be seen in Figure 7.

The XP217 models were tested to verify their performance over the operating temperature and voltage ranges. All four corner conditions were tested. The selected parameters tested included transmitter power



Figure 8: Dave and Joe (holding meter) test the XP217 in the freezer.

output, receiver sensitivity, and frequency stability. The kitchen freezer at the Monteiro residence was used for some of temperature testing as shown in the photograph of Figure 8. The XP217 was placed in the freezer and the cables were run through the door seals to the test equipment.

The high temperature testing was done using an apparatus consisting of a 100-watt light bulb in a fixture with a Styrofoam cooler to provide temperature stability. A thermocouple was used to measure the temperature.

After the testing was completed, the models were provided with a MIL-Spec (as per NASA-STD-8739.1) conformal coating using HumiSeal® type 1A33 polyurethane protective coating. This coating includes a fluorescent dye tracer and a short-wave ultra-violet lamp was used to inspect and verify the coating quality.

After the conformal coating, the units were functionally checked and then shipped to the US Naval Academy on November 30, 2005 for integration with the RAFT1 Satellite

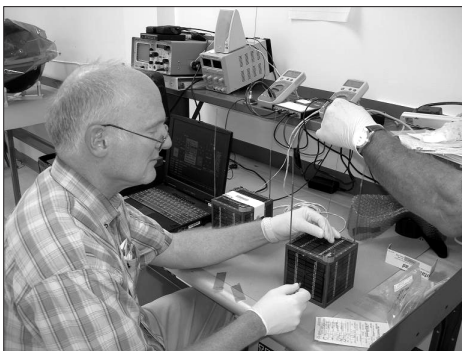


Figure 10: Bob Bruninga, WB4APR, puts the final touches on RAFT1.

RAFT1 Satellite Status

At the Naval Academy, the XP217 was integrated with the other RAFT1 components. The TX and RX side panels are shown in Figure 9 and the XP217 is clearly visible on the right (RX) panel.

In February 2006, the satellite construction was completed and it was then subjected to a battery of tests over the following months as required by NASA. On July 17, 2006 RAFT1 was delivered to the Kennedy Space Center for final testing and integration with the space shuttle. Figure 10 shows Bob, WB4APR, putting some final touches on the satellite. At the time this article was written, RAFT1 was awaiting its launch on Space Shuttle Discovery, STS-116. The launch is scheduled for December 2006.

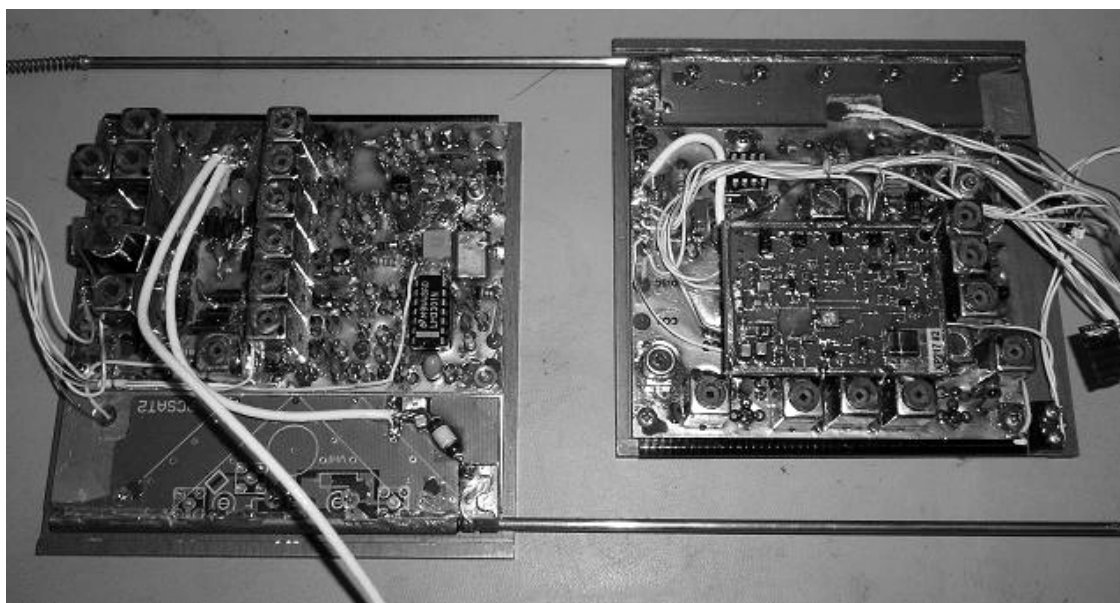


Figure 9: RAFT1 TX and RX panels with XP217.

Summary

The RAFT1 satellite was built by midshipmen at the US Naval Academy under the leadership of AMSAT member Bob Bruninga, WB4APR. The XP217 RADAR Transponder unit, which is the primary mission for the satellite, was developed by a team of AMSAT volunteers in the Boston area consisting of Dave Goncalves, W1EUI, Joe Fitzgerald, KM1P, and Tony Monteiro, AA2TX. Additionally, Tom Kneisel, K4GFG, provided invaluable assistance in understanding technical aspects of the AFSSS RADAR system.

Dave, W1EUI, created an XP217 Web site [10] with all of the design documents as well as interesting links. For the latest XP217 information please visit the Web site.

Footnotes

- [1] From the AMSAT-Bulletin Board, 29-JUN-2004. For more information see: www.amsat.org
- [2] AFSSS formerly known as the Naval Space Surveillance System or NSSS before handoff to the Air Force as described in "Military Role in Space Control: A Primer" by Adolfo J. Fernandez, National Defense Fellow. Published by the Congressional Research Service September 23, 2004.
- [3] NORAD: North American Aerospace Defense Command
- [4] RAFT Satellite Web site: <http://eng.usna.navy.mil/~bruninga/raft.html>
- [5] AFSSS Fence Image from National Space Security Road Map (NSSRM) unclassified photo list, <http://www.wslfweb.org/docs/roadmap/irm/photo.htm>

- [6] Tom Kneisel's NAVSPASUR Web site at <http://www.k4gfg.us/navspasur/index.html>
- [7] Lake Kickapoo Antenna photo courtesy of Tom Kneisel
- [8] EZNEC antenna modeling software available from: www.eznec.com
- [9] ExpressPCB printed circuit boards are available at www.expresspcb.com
- [10] The RAFT Tracking Device Development Web site is at <http://www1.coe.neu.edu/~dpg/rx217.html>



Canadian Member Training

MORE MEMBERS!

by Maurice-André Vigneault, VE3VIG, ve3vig@rac.ca

Amateur Radio Exhibit Group VE3JW

Ottawa Valley Mobile Radio Club at Canada Science and Technology Museum; Ottawa, Ontario, Canada

You may be aware of an increase in membership demands from the Ottawa area. As we train and graduate certified radio amateurs through a satellite communications course given at the VE3JW Amateur Radio Exhibit station located inside the Canada Science and Technology Museum in Ottawa, more Amateur Radio operators are interested in working on satellites and in the future of satellite communications.

We have put together a training program oriented towards the practical aspect of satellite communications with hands-on sessions at our excellent facility at VE3JW. To let you in on this project, and maybe guide you to set up similar training in your area, here is an announcement which is widely disseminated among our Amateur Radio community through Club Bulletins. The announcement is also at the VE3JW Web site, the Ottawa Valley Mobile Radio Club (OVMRC) Web site, and the Manotick Amateur Radio Group (MARG) Web site. It contains a list of subjects covered during the course.

The instructions are given with the help of a PowerPoint presentation. A study manual has been developed and a copy is handed out to each participant. It is available as a text file (~117k) by e-mail at ve3vig@rac.ca. So far, 16 participants have signed up, several have graduated and applied for membership into AMSAT. We're only getting started.

Satellite Communications Training

You've heard it before, "Amateur Radio's future is in space". Past accomplishments in space are warrant of our ability out there. NASA is ever more confident in that ability after assessing the many tasks we have performed for them. Amateur Radio on board the International Space Station is continually growing in importance as requested and approved by every astronaut who have been in the solitude up there. In recent weeks, discussions on how best to implement Amateur Radio for the soon-to-be station on the moon, to allow astronauts to vent off, have been on a positive note. The building of Phase 3E, Express and Eagle are well underway, as well as Phase 5A, ordered by NASA to orbit Mars.

Albeit, future in space is right now, if only you have a 2m radio. VO-52, AO-7, NO-44 and the ISS are a few satellites you can listen to for voice, packet, APRS, SSTV and school contacts. And some of them will allow you to uplink on 2m. FO-29, SO-50, and AO-51 have been working very well if only you have a little more equipment.

At VE3JW, your Amateur Radio Exhibit station, we have all the necessary equipment to carry regular satellite communications with the existing and the upcoming satellites. Not only is this equipment available for you to use, but we have set up a short course to help you get acquainted and work satellites.

The course is open to all certified radio amateurs and, comprises three 2-hour sessions which you can attend at your leisure, in your own time. Pick a date and time (7 days a week) from 10AM to noon, 1PM to 3PM or 3PM to 5PM. No charge for the course or entry to the Museum. Register with Maurice-André, ve3vig@rac.ca, tel: 613-749-9010 or VE3JW station 613-991-6749.

This course will introduce you to satellites, make you aware of the many factors having effect on their signals, and provide you with hands-on practice until you've completed contacts on your own. For a list of the subjects covered in the course see the outline at right.

Maurice-André Vigneault, VE3VIG
Amateur Radio Exhibit Group VE3JW
Canada Science and Technology Museum 

TRAINING FOR SATELLITES AT THE VE3JW STATION

1 - INTRODUCTION TO SATELLITES

- First AR Sat 1961
- Different Size
- Launch and Orbit
- Inclination, Anomaly, Attitude
- Squint Angle, Spin Modulation
- Polarization,
- Frequencies, Bands, Modes
- Inverting Transponder

2 - INTRODUCTION TO PRACTICAL

- Antennas
 - Handheld, Stack, Dish
- Radios
 - Handheld, Mobile, Base
- Split, Trace, Doppler
- Antenna controls
- Satellite tracking
 - Software
 - Keplerian Orbital Elements
 - Computer clock sync.

3 - WORKING SATELLITES - AUTOMATIC MODE

- Setting up the computer
- Selecting a satellite
- Setting up the radio
 - Automatic tracking
 - Automatic Doppler

4 - WORKING SATELLITES - MANUAL MODE

- A few examples
- Practical exercise

5 - WORKING THE ISS

- Ericsson, Kenwood, PCSat2
- Packet, APRS, Voice, SSTV
- Frequency selection
 - 145.800 MHz Downlink
 - Uplinks

6 - QSO info

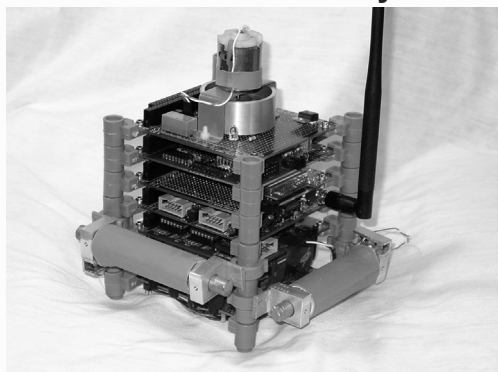
- Call
- Grid Locator
- Quality of signal
- Name
- QTH

7 - PAPER WORK

- Log
- QSL
- Awards



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Kenwood TS-790 and TS-2000
DDE client programs
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The author DK1TB donated SatPC32 to AMSAT. All proceeds support AMSAT.



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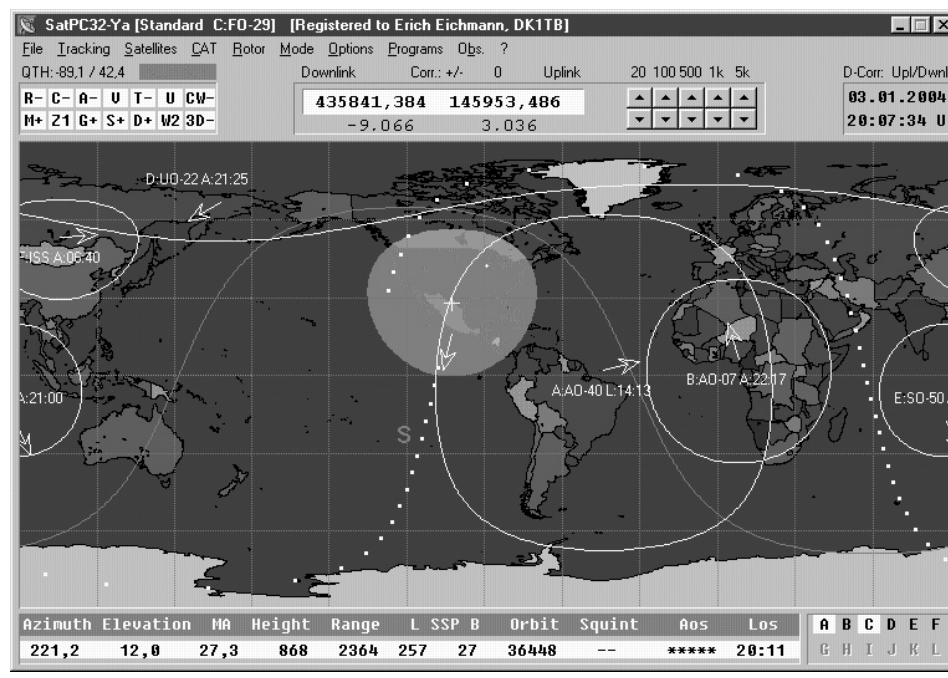
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AMSAT-UK Welcomes Foundation Satellite Access

The changes to the amateur license announced by Ofcom mean Foundation holders now have access to the Amateur Satellite Service. They will be able to work through the many amateur satellites as well use the voice and packet repeaters on the International Space Station (ISS). They can also talk directly to astronauts in space. All three astronauts currently onboard the ISS are licensed radio amateurs and in their spare time operate the ISS Amateur Radio Station usually on 145.800 MHz FM.

AMSAT-UK is delighted that the new license will allow full satellite access to Foundation holders. This will enable these enthusiastic operators to experience the thrills and challenges of space communications.

AMSAT-UK would like to thank the RSGB for its support in regards to this change.

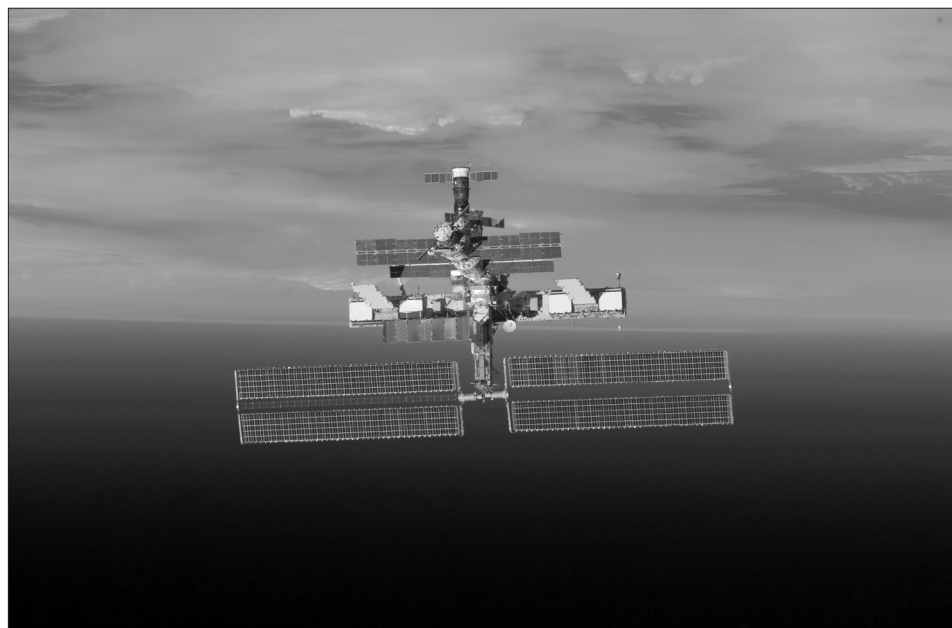
Every year AMSAT-UK runs a Satellite Beginners Workshop to teach newcomers how to operate through the satellites. Now that Foundation holders have this valuable new privilege AMSAT-UK can look forward to record numbers attending the next workshop.

AMSAT-UK produces a newsletter *Oscar News* packed full of Amateur Satellite information. For membership details contact the secretary Jim Heck, G3WGM.

Tel: 01258 453959

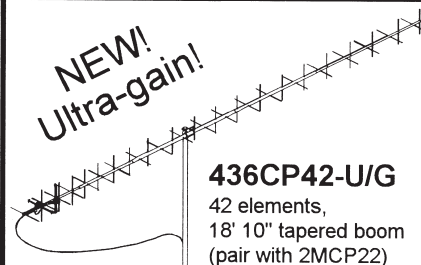
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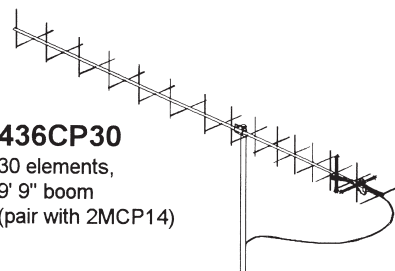
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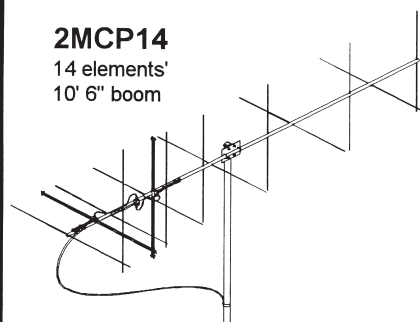
436CP42-U/G

42 elements,
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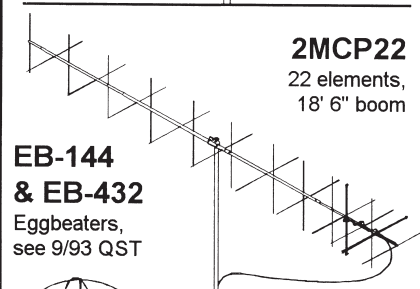
436CP30

30 elements,
9' 9" boom
(pair with 2MCP14)



2MCP14

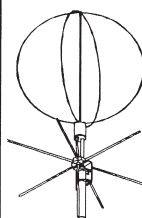
14 elements'
10' 6" boom



2MCP22

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18' 6" boom

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by Dick Jansson, WD4FAB
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73,
Ed Long, WA4SWJ
Editor, The AMSAT Journal

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Journal



The Orbital Classroom

"Education vs. Training"

© 2006 by Dr. H. Paul Shuch, N6TX, n6tx@amsat.org

AMSAT Director of Education



The Orbital Classroom

Do you know the difference between *education* and *training*? Although the AMSAT mission includes both distinct components (see sidebar), because the two endeavors often overlap, the two are easily mistaken one for the other. The distinction is a subtle but important one.

As a gross oversimplification, you can consider education as the imparting of knowledge, while training involves the acquisition of skills. In the context of satellite communications, prior knowledge is often necessary before specific skills can be acquired. Conversely, prior specific skills can often enhance or accelerate the accumulation of knowledge. That is why AMSAT's educational and training departments have to work together so closely.

In AMSAT, educational activities fall within my purview as Director of Education. I am tasked with developing curricula and materials to help the classroom teacher use our satellites as educational tools. Often, this has nothing whatever to do with completing a QSO and everything to do with the inner workings of the satellite or the outer workings of its orbit. If you think the only purpose of an HEO (high-Earth orbit) satellite is to facilitate making DXCC, you are missing its educational potential.

Training within AMSAT generally involves helping hams to operate the rig, track the bird and make contacts. It involves manipulative skills, thus requires hands-on practice with real equipment. AMSAT's training cadre is our growing network of volunteer Area Coordinators, organized through a structured Field Operations department, communicating largely through the Field Ops e-mail reflector. If you need a helping hand in making your station play properly, you can turn to Field Ops for swift and skillful training.

There is a lot of overlap between these two distinct areas, however, so AMSAT's educational and training departments collaborate extensively. As Director of Education, I often find myself helping a teacher to figure out the operation of a particular rig, for her to complete a classroom contact. And many are the Area Coordinators who have had to educate local hams in Kepler's laws so they could properly plug

them into their tracking software. Perhaps this is why the two distinct functions become blurred in the minds of many.

Satellites serve well as educational tools. They provide a concrete means for verifying scientific theory that to the student might otherwise seem abstract. By measuring acquisition of signal (AOS), loss of signal (LOS), and Doppler shift, for example, we can give students real-world data to test their understanding of orbital mechanics. But before such education can take place, one or more people in the classroom must be trained in the physical operation of the ham station. Otherwise, no practical data can be gathered to support the educational analysis.

Conversely, before the satellite ham can be trained in the tracking of the bird, a little formal education in coordinate systems (azimuth, elevation, right ascension, declination, latitude, longitude, and altitude) is probably in order. Without a solid educational background, operation reduces itself to "push this button, twist that knob, and hope for the best."

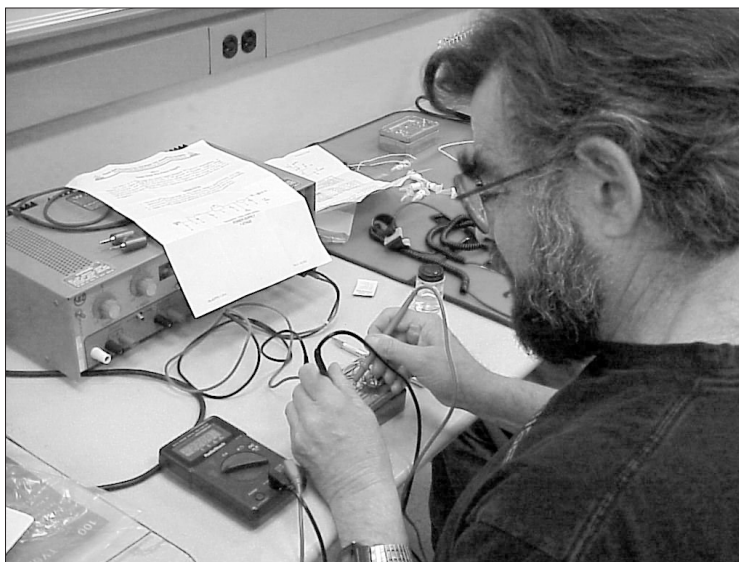
If education involves the acquisition of *facts*, training leads to a mastery of *tasks*. The factual emphasis in education is well suited to the classroom environment, so textbooks and the Internet make excellent educational tools. The task-oriented nature of training, on the other hand, means that it most often occurs in the laboratory. The ham station is

a laboratory of sorts, and thus an excellent training ground. When you show someone how to tune the rig, aim the antennas, key the mike, and make a satellite contact, you are training him or her in important manipulative skills. When you help a visitor to use these skills in calculating an orbit, evaluating Doppler shift, data-reducing a frame of telemetry, or predicting the next pass, you are engaged in education.

Still not convinced that the distinction between education and training is a significant one? Consider this: if you have school-age children, they probably receive sex education in the health science classroom. Sex training, on the other hand, most likely takes place extracurricularly. ☺

The AMSAT Mission Statement

*AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space **education**. We work in partnership with government, industry, educational institutions and fellow amateur radio societies. We encourage technical and scientific innovation, and promote the **training** and development of skilled satellite and ground system designers and operators.*



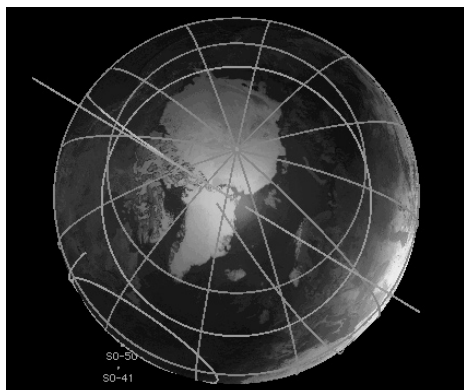
N6TX photo

Mal Raff, WA2UNP, was already highly educated, with a Ph.D. in astrophysics, when at a recent conference Ed Cole, AL7EB (now KL7UW), trained him in the construction of microstrip low-noise preamplifiers.



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AMSAT at the Tampa Bay Hamfest



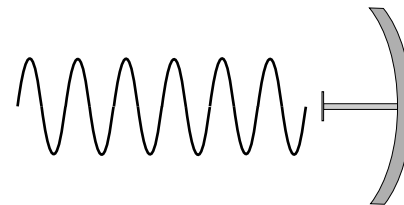
At the Tampa Bay Hamfest in Palmetto, FL on December 2-3, 2006 a group of AMSAT members attended and manned the AMSAT booth. Pictured above are from left to right: AMSAT Executive Vice-President Lee McLamb, KU4OS; AMSAT Vice-President Operations Drew Glasbrenner, KO4MA; AMSAT Journal Editor Ed Long, WA4SWJ; and AMSAT Area Coordinator David Jordan, AA4KN.



Pictured above are David Jordan again (l) and AMSAT Area Coordinator, Robert Davies, KI4HXT, manning the AMSAT booth during the day. Traffic was steady until the early afternoon.

An AMSAT Forum was presented by Lee McLamb and was very well attended. Lee focused on the upcoming Naval Academy satellites and GENESAT-1 and also presented information on P3E and Eagle. At the booth there was a PC running SATPC32, demonstrating both the tracking and tuning features with a Yaesu az-el rotor and a IC-910H. (Worked great! - Ed.)

Have you manned an AMSAT booth at your local hamfest? This is a great way to gain new members and generate interest in satellite operations. Contact Gould Smith at wa4sxm@amsat.org or Martha in the AMSAT office for assistance and information.



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Hamvention Award Nominations Deadline is February 19.

The Dayton Hamvention now is accepting nominations for its 2007 awards for Amateur of the Year, Special Achievement and Technical Excellence. The deadline for nominations is Feb. 19, 2007. All Amateur Radio operators are eligible. The winners will be recognized at the 2007 Hamvention, which runs May 18-20.

The Amateur of the Year Award goes to an individual who has made a long-term, outstanding commitment to the advancement of Amateur Radio. The Technical Excellence Award is for the person who has made an outstanding technical advancement in the field of Amateur Radio. The Special Achievement Award honors someone who has made an outstanding contribution to the advancement of Amateur Radio, usually someone who has spearheaded a significant project.

The Hamvention Awards Committee makes the decision on all awards based in part upon the information it receives - and not on the number of nominations submitted.

Documentation that informs the Awards Committee of a candidate's accomplishments may include magazine articles, newsletters, newspaper clippings, and even videos (these materials become the property of Hamvention and will not be returned).

Nominations are due by February 19, 2007. Additional details on these awards and a nomination form are available on the Dayton Hamvention Web site <<http://www.hamvention.org/nomination07.htm>>. Nominations also are accepted via US mail to Dayton Hamvention Awards, PO Box 964, Dayton, OH 45401. 📧



Yet Another OSCAR Grid Expedition

Bob Witte, KØNR, bob@k0nr.com

I found myself headed to Bonaire (grid FK52) in the Netherlands Antilles for a vacation in November 2006. The plan was to be there for 2 weeks, so clearly I needed to take along some radio gear. This sort of mini-DXpedition is always fun, so I took along some HF equipment and a basic FM satellite station.

Everything had to be transported via airline, so the radio gear needed to be compact. The satellite station was a typical VHF/UHF FM portable station consisting of:

- Kenwood dual band HT (TH-79A)
- Arrow II 146/437 dual band antenna with built-in duplexer
- Zen Nano Plus MP3 Player (for logging)
- Earbud headphones

The first problem I ran into was that AO-51 was configured in an interesting mode of SSB uplink (146 MHz) and FM downlink (435 MHz). My little HT can't do SSB, so I was locked out of AO-51 for the first week. In the second week of my trip, AO-51 was configured for 2.4 GHz uplink and 435 MHz downlink. OK, so I wouldn't be using AO-51.

Fortunately, another VHF/UHF FM satellite, SO-50, was available. In fact, it was *really* available. I had not been active on the satellites for quite a while and my experience was that the FM birds were usually jammed with activity. The first time SO-50 came over I didn't hear a thing. I even wondered whether I had the satellite tracking software set correctly. Daylight savings time had just changed in the US but Bonaire does not change time, so I thought my PC might be off by an hour. "Let's see, the computer thinks it is on Mountain Standard Time but it is located in Bonaire and what is the offset for UTC?" I fiddled with the software until I convinced myself that I had the tracking software configured properly.

I finally concluded that the SO-50 was just not that busy ... at least not on weekday afternoons in the southern Caribbean. Bonaire is approximately 12 degrees north latitude, near South America, so US stations were only workable for a few minutes of a pass. Then I realized that I normally rely on a signal on the downlink to adjust for Doppler shift and point the antenna. Without a signal, this became more difficult. (My HT doesn't

let me tweak the downlink frequency while transmitting.)

The next thing that happened was that I transmitted on the 2M uplink and heard terrible interference on the downlink frequency. It sounded like a local broadcast station was mixing with my uplink signal and showing up on the downlink frequency. Uh oh, this was really bad since it completely wiped out my ability to listen to myself on the downlink. There were several broadcast stations on the island, including Radio Netherlands, but I did not verify the source of the interference. Clearly, my poor little HT receiver couldn't handle it. I was really surprised by this as I had previously operated from many locations using this equipment without any problems. The interference problem was solved by finding a good spot on the island that didn't have the interference. Presumably, this was far enough away from the source of the interference to eliminate the problem.

I made a few skeds via email and finally got going on SO-50, using the call sign PJ4/KØNR. Bonaire falls under the CEPT licensing system so I was able to operate without any special application or permission. There was usually one or two good midday passes that worked out well as well as a few nighttime passes. Stations worked were N3UNM, N4ZQ, N3PKC, W5ACM, XE2AT, XE2ISS, XE1MEX, XE2YW, YV5DSL, YY5FRD and YV1DIG.

One of the challenges with this kind of operation has been the logging. In the past, I'd sometimes have someone jot down the information on paper as I worked the various

stations. This can be fast and furious so it is easy to miss important information. A better approach is to use a small cassette tape recorder to record the audio from the contacts.

I recently came across a nice upgrade to the audio tape recorder. Creative Labs produces a very small MP3 player called the Zen Nano Plus that has a built-in microphone and recording feature. I just clip this device onto my shirt as I work the satellites, making comments about call signs, grids, UTC, etc. into the microphone. Since I work the satellites full duplex, the downlink audio goes to my headphones and is not heard by the Nano Plus. I make it a point to repeat any important logging information. The Nano Plus does have a line input so you could run the audio from the receiver into the MP3 player and capture the downlink audio. This has the disadvantage of shutting off the microphone, so I have not used this approach.

There are multiple versions of the Zen Nano. The "Plus" version has the built-in microphone, which is essential for logging. Of course, the Nano Plus can be used for listening to music or other audio programs. It also has a built-in FM tuner. The Nano Plus is a remarkable device, available for less than \$50 on the Web.

I find these portable satellite operations to be a fun part of being on vacation. Activating PJ4 on SO-50 was a great addition to my holiday trip. The next time you find yourself traveling to a rare grid, think about taking along a basic satellite station. Thanks to the radio amateurs that took the time to work me in Bonaire. 📶

Photo 1: Bob, PJ4/KØNR, working SO-50 from the island of Bonaire.



WD9EWK's AO-51 V/S Adventure

by Patrick Stoddard, WD9EWK/VA7EWK, wd9ewk@amsat.org

For many years, I have been interested in Amateur Radio satellites and have been an AMSAT member. I made a couple of contacts via SO-50 in 2000, plus one contact via UO-14 in 2003, but I did not stay on the satellites. I read about AMSAT's plans for the S-band downlink for AO-51 during the 2005 Field Day, and I ordered a downconverter from K5GNA. I did not have enough time to figure out how to use this downconverter (and, for that matter, make any contacts via AO-51) before Field Day, so I put it away. After reading many posts on the AMSAT-BB mailing list, Drew, KO4MA's, V/S article in the July/August 2005 edition of *The AMSAT Journal*, and – finally – making a serious effort at working the satellites since December 2005, I decided I wanted to try out that downconverter. In early September 2006, I did that. And it was fun!



S-band downconverter.

My V/S Station

The downconverter from K5GNA, a modified TranSystem AIDC 3731 MMDS downconverter, came with an S-band dipole on one end and a corner reflector. I connected it to a Yaesu VX-2R HT and put a power inserter and 6dB attenuator in the RG-6 coax run between the downconverter and the radio. I used an adapter to go from the F connector on the coax to a male BNC connector (along with a BNC-to-SMA adapter, for the VX-2R's antenna connector), not concerning myself with the impedance mismatch between the downconverter and the VX-2R. Of the handheld radios I normally used with satellites (Icom IC-W32A and IC-T7H, Yaesu VX-2R), I could easily disable the transmitter on the VX-2R. A very good thing, to protect the downconverter from accidental RF coming from the receive radio. The VX-2R also had a built-in attenuator, which could be used if the signals from the downconverter swamped the receiver.

For my transmitter, I used an Icom IC-W32A with an Arrow Antennas 2m/70cm handheld Yagi. This is my normal FM satellite station, but for the AO-51 V/S configuration I turned off the 70cm side of the IC-W32A. I left the power level at 5 watts. I had been using the IC-W32A and Yagi to make the majority of my FM satellite contacts since December 2005, so I was very familiar with this combination.

The transmit radio had the standard AO-51 2m FM uplink frequency, 145.920 MHz with 67.0 Hz PL. The receive radio was initially set at 145.250 MHz, which would be approximately equal to the 2401.200 MHz AO-51 downlink frequency and compensating for the Doppler effect at the start of the pass (+50 kHz). I left the VX-2R in VFO mode, since I would be tuning down in 5 kHz steps throughout the pass, and connected an audio splitter to the speaker-microphone jack so I could listen to the pass without causing feedback and record the audio with my Sony digital recorder.

First Attempt

I saw that the V/S voice configuration would be active on AO-51 between 28 August and 3 September and I was determined to make some time to try out the downconverter and – hopefully – log some contacts. The first opportunity I had during that week was Thursday evening (Friday, 1 September, UTC time). There was a pass in the evening to the east, which would cover most of North America, which could provide the best chance to hear other stations and make contacts. I made sure I had my equipment in my car, since I would be out running errands on this Thursday evening. A thunderstorm passed through the Phoenix area an hour before a 39-degree AO-51 pass at 0317 UTC (2017 local time), but the skies cleared enough so I could safely operate my radios.

I parked in a church parking lot in northeast Phoenix (grid DM43ap), and put my radios and antennas on the roof of my car. I planned on holding the IC-W32A and Yagi while transmitting, and then setting the radio and/or antenna down so I could make adjustments to my receive frequency on the VX-2R and turn the downconverter to hear the satellite. About 2 minutes into the pass, I found the AO-51 downlink and could hear a contact in progress. About 2 minutes after that, at 0321 UTC, I made my first V/S contacts with N5UXT in Louisiana (EM40) and WA4EWV in Florida (EM70). Success! The downconverter worked very well, and it was easy to hear AO-51 and keep up with the Doppler through the pass.

If these two V/S contacts were the only two I could make during this week, I would have been happy. I was determined to try again, and hopefully add more V/S contacts to my log before AO-51 switched to its next configuration.

Friday Morning, with Daylight

After the success I had the night before, I took my V/S equipment to work with me. I planned on trying AO-51 during one pass this Friday morning (1 September 2006), a 40-degree pass favoring western North America at 1707 UTC, from outside my office near downtown Phoenix (grid DM33xl). I took a break from my work, and went out to my car to get ready for the pass. It was a sunny morning, and I could hear the AO-51 downlink about 90 seconds into the pass.



The complete S-band setup on top of the car.



I heard other stations making contacts and when there were breaks in the contacts I announced my call sign. In the span of approximately 5 minutes, I made 3 contacts – W7JPI in southern Arizona (DM41), W0LMD in Colorado (DM79) and KU7Z in Utah (DN41). My portable station was working, and I'm hooked! Other than having to constantly keep up with the Doppler effect on the downlink signal, this was getting easier. I was now determined to get on for more passes over the upcoming weekend.

Saturday Morning, from a Park

I was doing some yard work this morning (2 September 2006), missing one AO-51 pass, but I planned to try for a pass around 1807 UTC. This would be a lower pass to the west, with a maximum elevation of 10 degrees, a great test of my portable V/S station. To have the best chance of hearing the satellite, I drove to Paradise Valley Park, a city park north of my house that straddles the DM33/DM43 grid boundary and prepared my station.

Hearing the satellite was surprisingly easy. As long as AO-51 was above 3 or 4 degrees elevation, I could hear the satellite. Unfortunately, I heard no other stations on the downlink. I used this pass to test my ability to transmit through the satellite and hear the downlink. I was disappointed nobody else showed up for this pass, but I knew there were still more passes I could try before the V/S configuration was turned off.

Sunday Morning

I had some free time this morning (3 September 2006), and I was determined to work the two morning AO-51 passes. There was a 32-degree pass to the east starting at 1548 UTC, followed by a 26-degree pass to the west starting at 1727 UTC. I went back to Paradise Valley Park on the DM33/DM43 boundary, set up my portable station on the roof of my car, and waited for AO-51 to appear.

This was a busy pass. I heard several quick contacts at the start of the pass and I was able to get my call sign on the downlink. In a 7-minute span (1550-1557 UTC), I made 7 contacts! I worked W0LMD and KU7Z again, plus 5 others: N8BBQ in Ohio (EN91), W2NBJ in Maryland (FM19), KB0JQO in Iowa (EN32), WA4SCA in Tennessee (EM65) and AI7W in Oregon (CN84).

For the last pass of the morning at 1727 UTC, I operated from my driveway at home (grid DM43ao). I heard W0LMD and KU7Z again, made contacts with both of them and had a nice chat before the satellite went away from us. By now, operating these two separate radio/antenna combinations became easy. I had no problems tuning the receive radio to keep up with the Doppler effect on the S-band downlink.

Observations

I made a total of 14 contacts with stations in 10 US states and 10 grids, from 4 locations in Phoenix. The 2401.200 MHz AO-51

downlink was easy to receive and the Doppler shift was not impossible to deal with despite having my hands full with two separate radio/antenna combinations and no computer control. I sometimes turned the downconverter with its dipole/corner reflector antenna 90 degrees to deal with the changing polarity of the downlink signal. I did not have to point the downconverter directly at the satellite to hear it and at some points I was 45 to 60 degrees away from the satellite and still had a signal in my receiver.

Since this was the first time I tried receiving anything in the 2.4 GHz band I did not know if I would encounter interference from WiFi devices or cordless phones that also inhabit this band. I had no problems hearing the satellite from any of these locations. I was concerned I might cause interference with my receive radio (VX-2R) while transmitting since both radios would be on the 2-meter band separated by a few hundred kHz. This was never an issue. The only way I heard myself was on the AO-51 downlink, not from overloading the receiver with my transmitted signals.

Future Plans

After these passes, I am now a fan of AO-51's V/S FM voice configuration. I will look forward to it showing up on the schedule in the future. This is something I can do from home or almost any other location where I am able to set up my station – on the roof of my car, a picnic table in a clearing, etc. I hope to hear you on V/S! 📶



This is a picture of an historic event for AMSAT. It was the first official meeting between AMSAT, the University of Maryland Eastern Shore (UMES) and the Maryland Hawk Corporation on Tuesday, October 17, 2006 to discuss potential future relationships, including the establishment of a new AMSAT satellite integration lab. The dinner was held in the private dining room of the UMES President and was catered by the students and faculty of the UMES Department of Hotel and Restaurant Management. Front Row, L to R: Richard M. Hambly, W2GPS, AMSAT President; Thelma B. Thompson, Ph.D., President, University of Maryland Eastern Shore. Rear Row, L to R: Dick Jansson, WD4FAB, AMSAT Engineering Team Member; Dr. Robert W. McGwier, N4HY, AMSAT VP Engineering; Dr. Ronald G. Forsythe, Jr., UMES Vice President for Planning, Assessment, Technology and Commercialization; Ron Bettini, Executive Director, Hawk Institute for Space Sciences (a division of the Maryland Hawk Corporation); Dr. Thomas A. Clark, K3IO, AMSAT Director and President Emeritus; Quentin R. Johnson, Special Assistant to the President, University of Maryland Eastern Shore; Robert J. Davis, KF4KSS, AMSAT Engineering Team Member and an employee of Hawk Institute for Space Sciences.



Introducing the Party of Suitsat-1 and Debris: All Dressed Up and Nowhere to Go but Down.

by James A. DeYoung, KG4QWC, kg4qwc@arri.net

The most common question asked related to SuitSat-1 (SS-1) was why the received signals on earth were so low in strength. The source of the SuitSat-1 debris (SS-1 (deb)) was another common question posed. I wondered about the possibilities, but like many others initially had no definitive answers to offer. However, later random Web surfing brought a providential finding of a link to a video of the SS-1 deployment space walk, which ultimately lead to the serendipitous discovery of a piece of debris floating off just before SS-1 release. Fortunately, the video quality and camera gain setting were good enough to allow the debris to be found, measured and a few characteristics to be determined. The proposed SS-1 (deb) object found during this work appears to be a likely candidate for the space-track.org object. The identified debris and other observations do not support any theories related to a piece separating from SS-1 post-release to account for the weak signals as observed on the ground. This paper will present information related to the observed orbital decay of SuitSat-1. A possible candidate for the SS-1 (deb) is identified, the decay modeled and apparent details of the object discussed.

Orbit Modeling

The Semi-analytic Theory of Motion under Air-drag and Gravity (STOAG) [1,2,3] was used to model the SS-1 and SS-1 (deb) decay. STOAG models drag semi-analytically using the actual observed solar flux and daily average geomagnetic A-index and also accounts for seasonal and geographic variations of the thermosphere. The geopotential is analytically modeled to ninth-order harmonic terms (J9). The STOAG model also assumes that the spacecraft shape is a cannonball. According to the authors, STOAG is useful for modeling the long-term evolution of low-earth orbit (LEO) satellite orbital motion for mission planning, lifetime prediction and space debris dynamics.

SS-1

Some common designations for SuitSat-1 are, 28933, 05035C, Radioskaf, and AO-54. Two-line elements (TLE) from the Space-Track Web site [4] were imported and apogee and perigee height above the ellipsoid for each day were determined using NOVA for Windows [5]. Finally, the perigee and apogee were averaged to make a mean height. All of this was done using a spreadsheet program and plots were generated, see Figure 1. SS-1 took 215.7 days from release to complete decay.

One of the important factors in determining time to decay is called the ballistic number (BN). See equation 1.

$$BN = M/A * Cd \quad (1)$$

where mass (M) is in kilograms, the area (A) is in meters², and Cd is a shape and material dependent constant. The relationship says that if BN or M/A increases there is a slower rate of drag induced lowering of the orbiting objects height relative to the lower value.

When modeling orbits Cd is commonly set to a value of 2.2, which is appropriate for spherical objects (cannonballs). The cannonball model is what STOAG uses. SS-1 is clearly not a cannonball so simple average equivalent areas are used. When SS-1 was released it was tumbling on all three-axes. SS-1 probably relaxed into a flat-spin with respect to earth nadir due to forces acting on the flexible appendages. SS-1 was observed optically and video captured by Kevin Fetter of Brockville, Ontario, Canada [6]. SS-1 was clearly still tumbling on 18 April 2006, day +108 from release and on 11 August 2006, day +189 [7,8].

To start the STOAG modeling of SS-1's orbit, initial conditions were obtained from the space-track.org TLE whose epoch was 06035.17648092. SS-1's mass was fixed at 97.5-kg [9], an average drag area was estimated as 1.38-m², and Cd was adjusted for best fit of the mean height. A reasonable fit to the decay was found using a Cd of 0.895.

Using equation 1, a value of BN (SS-1) = 97.5-kg/1.38-m² * 0.895 = 63-kg/m² is computed. This number seems reasonable and is within the range of 48 to 134-kg/m² specified by Frank Bauer, KA3HDO [9].

SS-1 (Deb)

Some additional common names for SS-1 (deb) are 28934 and 05035D. SS-1 was released at 23:03 UTC 3 February 2006 [10]. Space-track.org first reported the debris in TLEs five days after the SS-1's release. Several theories have been offered for the debris identification including a glove, a boot or the student CD-ROM [11,12]. My favorite was that the antenna broke off and became the debris. Some of the proposed objects could account for the weak signals observed on the earth, however inspection of the space

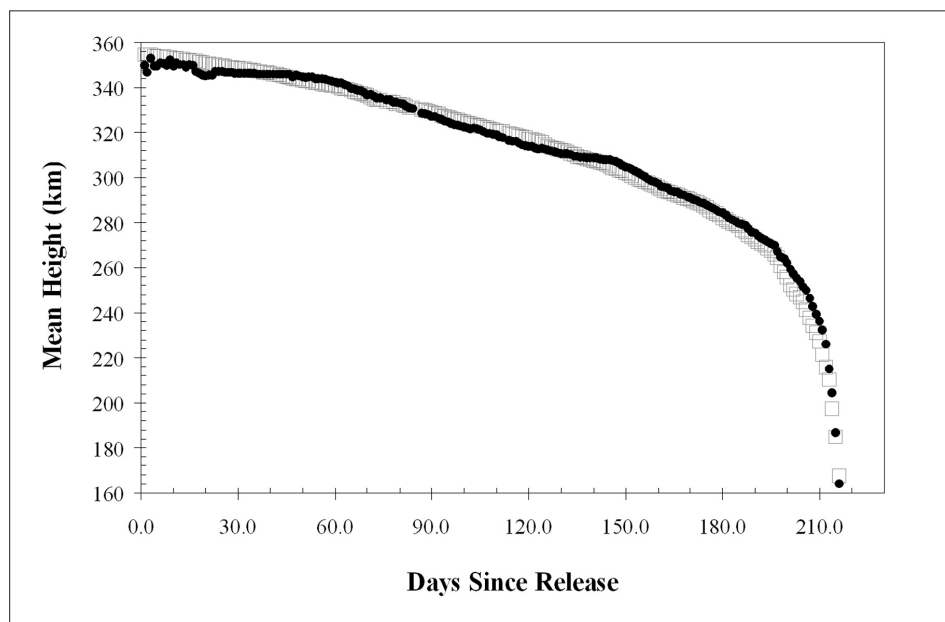


Figure 1: This plot shows the observed (filled circles) and STOAG modeled (open squares) orbit evolution of SS-1 from its release from the ISS to decay. The mean heights plotted are the simple average of perigee and apogee height above the ellipsoid for each day. The actual decay date for SS-1 is 7 September 2006 16:00 UTC, day +215.7.



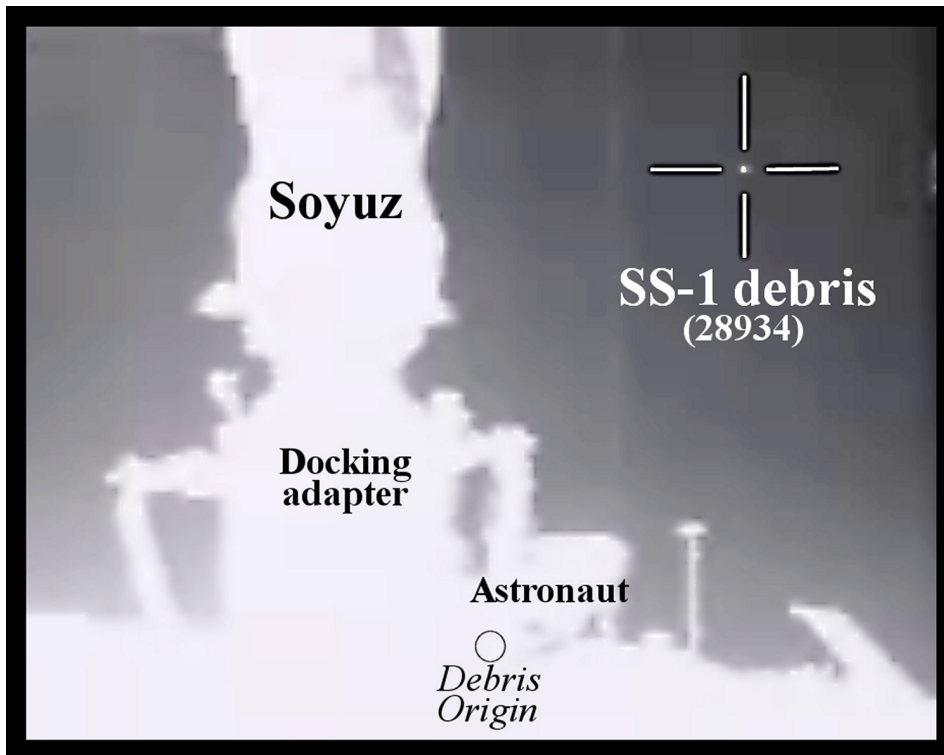


Figure 2: This is a captured image from the NASA Select TV video showing several components of the ISS, the apparent debris origin and the proposed candidate for the SS-1 (deb). Nadir is approximately up in the image and forward track is to the left.

walk video and still images seem to indicate that all was attached firmly post release.

I didn't watch the space walk in real-time but later did find a video media file on a Web site [13]. While viewing the media file, an easily observable object was noted drifting away from the ISS a few minutes before SS-1 release, see Figure 2. The gain on the video camera was set high initially and the object was seen for 23 seconds until the camera gain was adjusted down by a significant amount as the object was reaching the edge of the frame. The debris was not observed at its source location because another camera was selected at the initial drift off time and the debris was not in its view. It was determined by extrapolation of the drift off rate and direction, assuming that the debris originated near the space walk activities, that the observed debris began its drift off 2.283-minutes before SS-1 release originating near the circle plotted in Figure 2. If we assume the debris is at the same distance as the Soyuz and the astronaut we can estimate a size. The object is slowly tumbling and is clearly not symmetrical in shape. Allowing for camera gain bloom and using the diameter of the bulbous section of the Soyuz as a reference diameter an estimated average value of the presented area of the debris was determined to be 0.016-m^2 .

Initial conditions for starting the STOAG model were obtained from the first Space-

Track TLE whose epoch is 06040.31462003. The orbital decay was modeled with STOAG using an estimate of 0.016-m^2 , Cd of 2.2, and adjusting the mass resulted in a statistically reasonable fit using a mass of 0.53-kg. Using equation 1 we determine BN (SS-1 (deb)) = $0.53\text{-kg}/0.016\text{-m}^2 * 2.2 = 73\text{-kg/m}^2$. An everyday object that would present a similar drag area and mass would be a $\frac{1}{2}$ -liter plastic bottle of water.

Discussion and Conclusions

There are at least several still images [14,15] in addition to the initial release space walk video, which show all the important parts of SS-1 as intact and well connected after release. Radar cross sections were reported for the SS-1 (deb) by space-track.org [4]. Initially, 0.04-m^2 was reported for the debris, however 0.0057-m^2 was reported post decay. The average of these two RCS areas is 0.023-m^2 , which is in fair agreement with the average area estimate by this author, 0.016-m^2 , from the space walk video. The probability is high that the debris candidate identified in this paper drifting off a few minutes before SS-1 release is the space-track.org SS-1 (deb) object. The results presented in this paper do not strictly rule out the possibility that some piece detached from SS-1 that affected transmitter performance, but in my view this is not very likely. If the SS-1 (deb) identified in this paper is indeed the same object reported by space-track.org then the fact that low signal levels were observed during the mission would need to be accounted for by some other mechanism.

References

- [1] Bezdek, A., Vokrouhlicky, D., 2004, Semianalytic theory of motion for close-Earth spherical satellites including drag and gravitational perturbations. Planet. Space Sci. 52(14), 1233-1249.
- [2] Bezdek, A., 2004, Semianalytic theory of motion for LEO satellites under

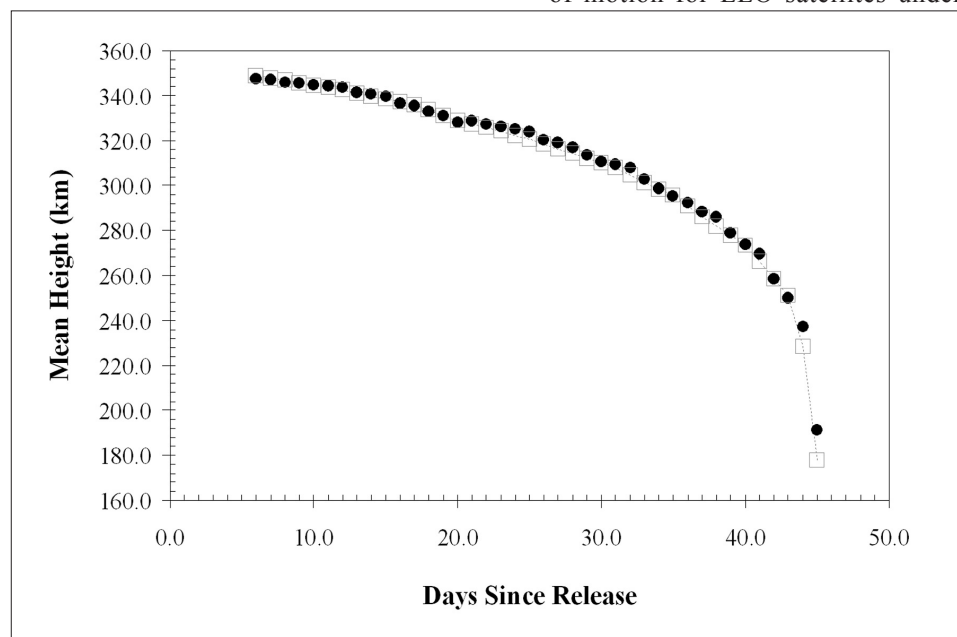


Figure 3: This plot shows the observed (filled circles) and STOAG modeled (open squares) orbit evolution of SS-1 (deb) from its release from the ISS to decay. The mean heights plotted are the simple average of perigee and apogee height above the ellipsoid for each day. The actual decay date of SS-1 (deb) was 20 March 2006, +day 45.

air drag. In Proceedings of the 18th International Symposium on Space Flight Dynamics, Munich, Germany, Oct. 11-15, ESA SP-548, 615-620.

- [3] http://proxyon.asu.cas.cz/~bezdek/density_therm/pohtd/index.php
- [4] <http://www.space-track.org/>
- [5] <http://www.nlsa.com/>
- [6] <http://www.kfetter.com/setup/videosetup.htm>
- [7] <http://www.kfetter.com/satvideo/041806/28933.wmv>
- [8] <http://www.kfetter.com/satvideo/081106/28933.wmv>
- [9] Private email communication from Frank Bauer, KA3HDO
- [10] <http://www.arll.org/news/stories/2006/02/03/103/?nc=1>
- [11] Frank Bauer, KA3HDO, "Suitsat Wrap Up", *The AMSAT Journal*, Vol 29, No. 2, March/April 2006, pp. 19-20.
- [12] <http://www.arll.org/news/stories/2006/02/24/1/?nc=1/>
- [13] <http://pd0rk.ontwikkel.nl/>
- [14] <http://antwrp.gsfc.nasa.gov/apod/ap060220.html>
- [15] http://antwrp.gsfc.nasa.gov/apod/image/0602/suitsat1_nasa_big.jpg

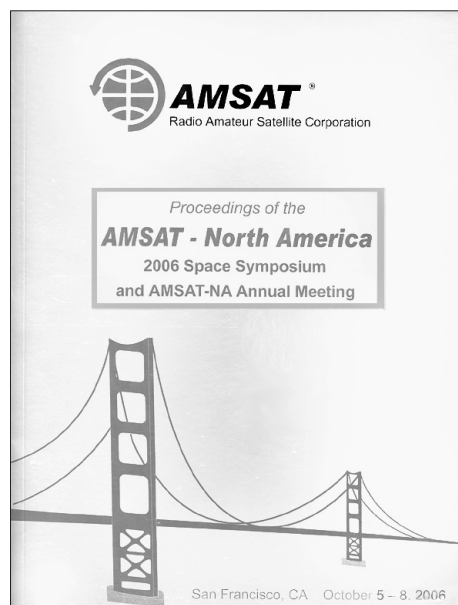
New Items in the AMSAT Store!

The AMSAT online store now features two new items!

Proceedings of the AMSAT 2006 Space Symposium

The first is the Proceedings of the AMSAT 2006 Space Symposium. This volume of technical papers includes the articles produced by our colleagues who presented at the Symposium. Articles include antenna construction plans and techniques, information about new LEO and Cubesat developments, satellite frequency planning and coordination, and an extensive update to the design and construction of AMSAT Eagle.

The Proceedings contains 284 pages chocked full of information about the future of Amateur Radio satellites. Cost is \$20 plus shipping and handling.

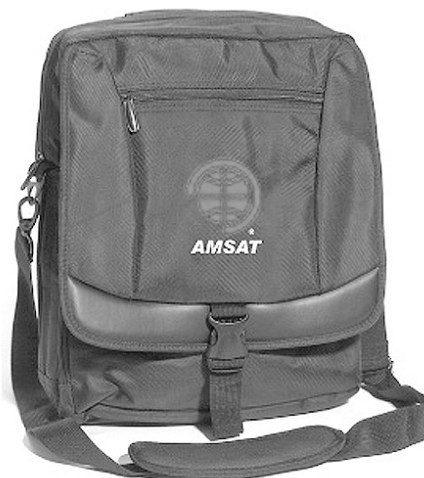


The AMSAT Computer Backpack!

This backpack was produced as a gift to the recipients of the 2006 AMSAT Presidential Achievement Award and was such a big hit at the Symposium we decided to order more and sell them through the store.

The backpack features a padded computer pouch and room for accessories in the main compartment and a deluxe organizer for business and computer accessories in the front and. There is an additional interior cell phone pocket that is accessible through a zipper on the outside. The hideaway adjustable padded backpack straps stow inside a back pocket when not in use, and the pack also comes with a detachable adjustable shoulder strap if you would prefer to use it as a "messenger" bag.

Cost is \$55 plus shipping and handling. AMSAT members save \$5 if you order it online!



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AMSAT Eagle Update

James A. Sanford, PE, WB4GCS, wb4gcs@amsat.org

Eagle Project Manager



Our Vision is to deploy high earth orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012...

Good things are happening with Eagle since the last *Journal*. First, the 70cm receiver Peer Review is complete. There remains one open item regarding receiver local oscillator phase noise requirements, which Bob McGwier, N4HY, Phil Karn, KA9Q, and John Stephenson, KD6OZH, are resolving. We can then approve the design and authorize construction and testing of a prototype.

Juan Rivera, WA6HTP, has drafted an Acceptance Test Plan (ATP) for the 70cm receiver and has assembled a team to build and test the prototype. I have seen a preliminary version and it is impressive. Based on the ARRL *Test Procedures Manual* and enhanced with John's professional experience in industry, it will be a rigorous, well-documented set of tests. Juan will submit a final draft for peer review by the time that you read this. It is my hope that this peer reviewed acceptance test plan and the final approved ATP will become a model for other Eagle test plans. Although improvements are inevitable, it is my goal that each component of Eagle will be tested in a similarly rigorous way, allowing comparative evaluations of processes and results. Look for Juan's ATP on EaglePedia over the next several months. Eventually, you will see prototype photos and test results on EaglePedia.

Speaking of EaglePedia, Emily Clark, N1DID, has just completed a significant upgrade of EaglePedia. This upgrade will improve EaglePedia performance and utility. In addition, Dave Hartzell volunteered at the Symposium to help me with administration and management of EaglePedia content and

structure. Dave has saved me tons of time, and made some organizational changes to the pages that make EaglePedia MUCH easier to use, both for casual browsing and for authors posting documents. Thanks Dave and welcome to the team! Finally, the AMSAT leadership has decided to increase member access to EaglePedia pages. As a result, the only things that are not totally public are those few things that really need to be discussed internally, before they are even *half-baked* and ready for public discussion. Although some would like *everything* to be totally "open", team members need some discrete forum for internal discussion, especially the "passionate" discussion. Personally, I think we've struck a very good balance between openness and not stifling internal discussion – time will tell. Browse the new EaglePedia and please send your feedback directly to me. In the future, look for a page where any AMSAT member can input a question, suggestion, or comment, which will be evaluated and posted on an Eagle FAQ page.

The Eagle team has recruited several new volunteers, including experienced microwave RF designers, sensor and control loop designers and embedded systems designers. This new (to us), but very seasoned, talent will help us spread the workload and accelerate development of Eagle components. Your Eagle team is becoming the most powerful collection of intellect that I've ever had the pleasure to be around.

The most exciting news this month involves our new integration facility and lab. As Rick Hambly, W2GPS, describes in his

Apogee View, we have signed Memoranda of Agreement with The University of Maryland Eastern Shore and the Hawk Institute for Space Sciences. These arrangements give us access to a nice facility, access to resources, and possible access to volunteers and students willing to help out in the facility.

Elsewhere in this issue, Bob, N4HY, describes in much more detail all aspects of the facility and the agreements. This is VERY good news for Eagle, which will be one of the first and largest uses and users of the new facility.

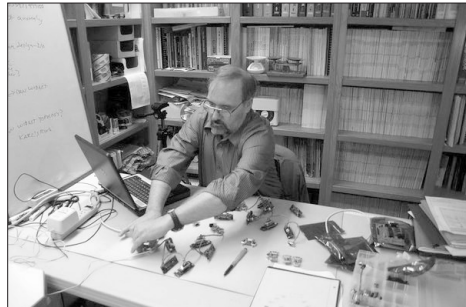
Finally, there has been significant effort on hardware that will fly in Eagle. N4HY; Bdale Garbee, KB0G; Chuck Green, N0ADI; Steven Moraco, KC0FTQ; and Lyle Johnson, KK7P, gathered at Lyle's QTH in early November to work on issues with the IHU and the fault-tolerant version of the CAN bus. The three photos provide an idea of the participants, work and facilities. Thanks to Lyle and his XYL for hosting this crowd, and thanks to the gang for the great progress. Look for an update on EaglePedia.

By now, you've probably heard that the next *AMSAT Symposium* will be held in Pittsburgh, PA. Arrangements are being coordinated by Pat, KC4WTT, Kevin, N3HKQ, and many members of the Wireless Association of the South Hills (PA). They are looking forward to hosting you. Before it's all done, several Pittsburgh-area clubs will be involved. The selected facility is very well equipped for our needs and I expect that the Eagle team will have much to discuss and demonstrate. Do plan to be at the next *Symposium*.

As always, questions to, wb4gcs@amsat.org

73,
Jim

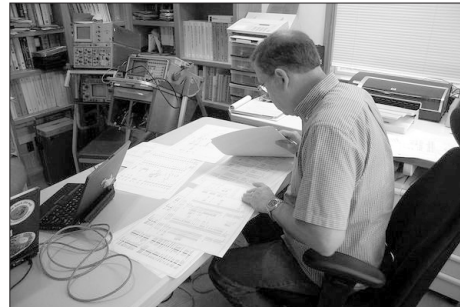
Steven, KC0FTQ prepares for IHU and CAN-Do! module tests.



Chuck, N0ADI, with components and stereo microscope.

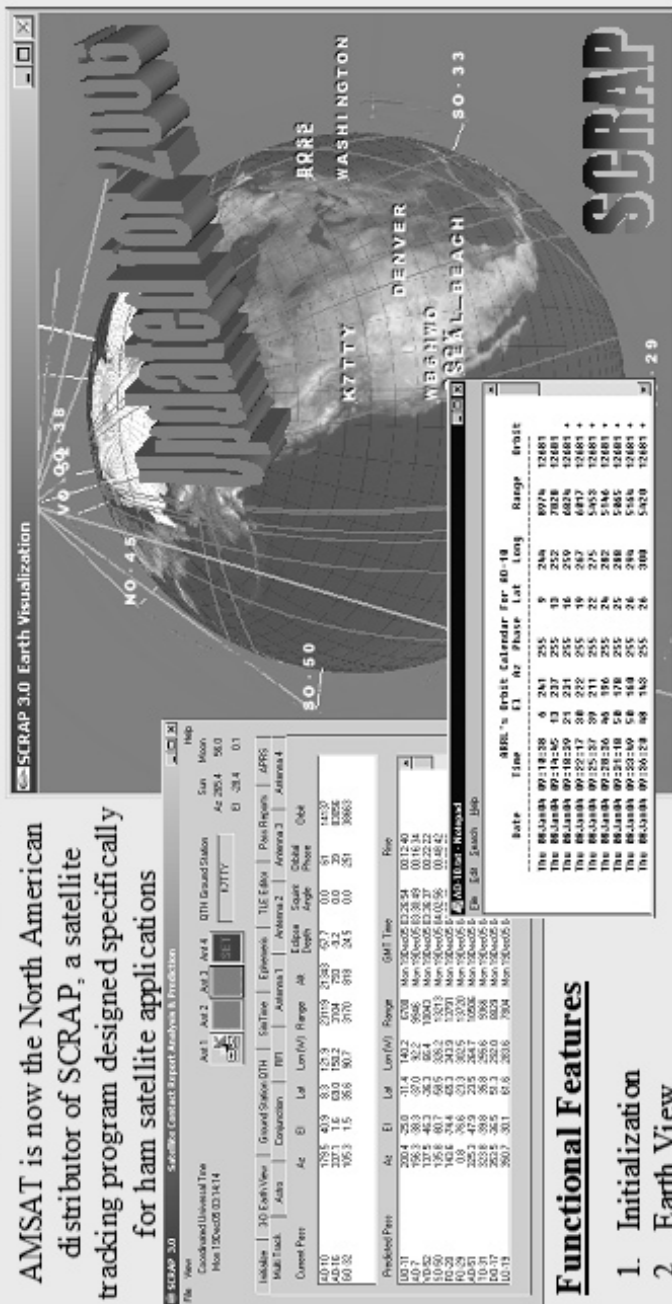


Lyle, KK7P, studies netlists and schematics.



Satellite Contact Report Analysis Prediction 3.0

AMSAT is now the North American distributor of SCRAP, a satellite tracking program designed specifically for ham satellite applications



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Recommend minimum processor

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Put P3E into Orbit and Join the Pixel Action

by Frank Sperber, DL6DBN/AA9KJ and Heike Straube

AMSAT-DL has created a special opportunity for individual participation and support of the successor to AO-10, AO-13 and AO-40 that is currently under construction. All are invited to visit the newly established Internet Web site, www.p3e-satellite.org to support this technical challenge through the purchase of pixel fields and to become part of this ambitious Amateur Radio project.

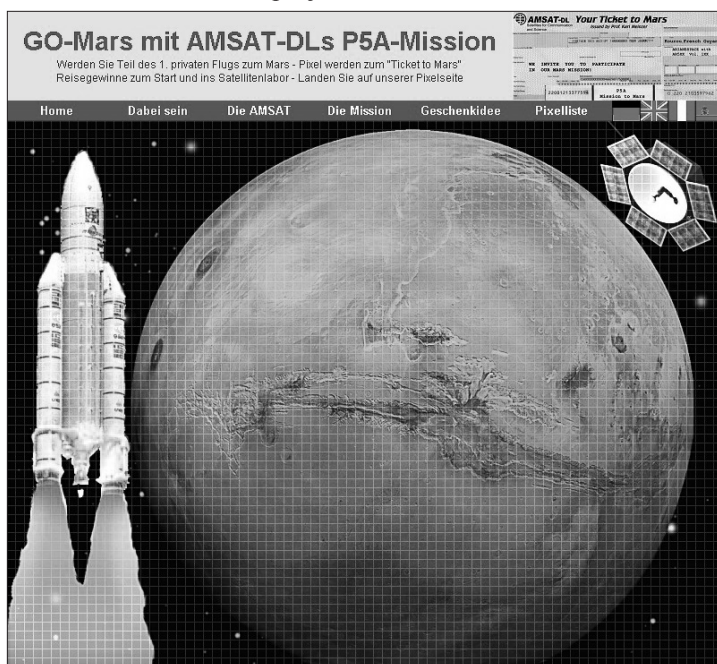
All together, 4,800 fields of 10x10 pixels can display your name, call sign, a personal picture or logo. Depending on your donation limit to the project, you can reserve as many fields at 50 Euros each as you wish. The background image is a view into the new satellite with its 17 electronic modules.

As special thanks, we will prepare a personal certificate for download at the end of the order process and you can win a raffle for exclusive travel to the satellite laboratory and to the launch of P3E. The one who takes the most pixels automatically earns a trip to the launch. Additional trips will be raffled off among the remaining participants. During a visit to the P3E laboratory you can experience close up the construction of the satellite through its critical phases. The trip to the launch, which includes being guest of honor at the launch party, promises to be a unique experience.

Such an exceptional way of being able to participate in an Amateur Radio project



Picture 1: The P3E satellite forms the optical background of the AMSAT-DL auction, which offers prizes for exclusive trips to the satellite laboratory and to the launch.



Picture 2: Two additional motives for the Mars Mission should also animate interested persons outside of Amateur Radio to support the Mars project.

will certainly not happen again very soon. Following the launch of the Internet site www.p3e-satellite.org on September 1, 2006, you have the best chance to go there yourself. As a special feature there is also the possibility of giving pixel fields to friends or family members. A special gift card can be ordered and personalized for the recipient.

During the AMSAT-UK Colloquium we tested the project called "Pixel Auction" before an international audience. Three certificates for the allocation of the first three fields were auctioned for around £750 among the participants. The response to this auction was enormous and will certainly spread internationally.

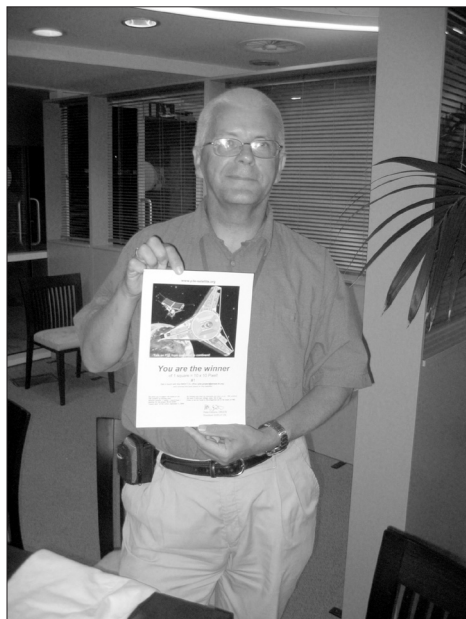
A second pixel action is also currently running in parallel to support the AMSAT Mars Mission. It is directed at an expanded target group of individuals whose technological interest goes beyond Amateur Radio. Under the same conditions, pixel fields can be reserved under www.Ticket-to-Mars.org on two different pictures.



Reservation of pixels and entry of the requested information is performed in several steps. The data transmission occurs over a secure connection and payment may be made by wire transfer, via credit card or through PayPal, the eBay payment service.

For both auctions flyers are available, which you can use to inform and encourage colleagues, friends, family or co-workers to join in.

We look forward to numerous clicks and a high level of participation in the auctions, which will support further work on the missions. ☺



Picture 3: During this year's AMSAT-UK Colloquium the idea for the pixel auction was tested before an international audience. Dave Johnson was the lucky winner, who won the first auction for three certificates for a pixel field.

www.Ticket-to-Mars.org

Landen Sie mit Ihrem Namen, Link, Logo oder Text auf dem Mars, bevor wir dort ankommen!

Schreiben Sie Raumfahrtgeschichte:

Tragen Sie sich in unsere Pixelliste ein, und werden Sie Teil eines ambitionierten Raumfahrtprojekts zum

ROTEN PLANETEN!

Land on Mars with your name, link, logo or personal message before we arrive!

Write space travel history:

By joining our pixel list you will become part of an ambitious space travel project to the

RED PLANET!

Wie kann ich dabei sein?
Klick: www.Ticket-to-Mars.org

Wir laden Sie ein, mit der Belegung von Pixeln diese technische Herausforderung zu unterstützen.

Mindestabnahmemenge:
1 Feld = 10 x 10 Pixel

Gewinnen Sie eine von mehreren Reisen zum Start der P5A-Marssonde im europäischen Weltraumbahnhof in Französisch Guayana oder zu Integrationslabor und Kommandostation von P5A!

AMSAT-Deutschland e.V.
Ernst-Giller-Str. 20
D-35059 Marburg
Germany

Phone No. +49-6421-684112
Fax No. +49-6421-2825665
E-Mail: office@amsat-dl.org
Internet: www.amsat-dl.org
www.go-mars.org

How can I get involved?
Click: www.Ticket-to-Mars.org

We invite you to support this technical challenge by choosing pixels.

Minimum quantity:
1 square = 10 x 10 Pixel

Win one of many trips to the launch of the P5A space probe from the European Spaceport in French Guiana or to the integration facilities and the base station of P5A!

Project and donation account
Account no. 16509612
Volksbank Mittelhessen (BLZ 513 900 00)

IBAN: DE84 5139 0000 0016 5096 12
SWIFT-BIC: GENODE51G11

AMSAT-DL Your Ticket to Mars
Satellites for Communication and Science
Issued by Prof. Karl Meinzer

WE INVITE YOU TO PARTICIPATE IN OUR MARS MISSION!

P5A Mission to Mars

TALK ON P3E

from Continent to Continent!

www.P3E-Satellite.org

AMSAT-DL

Dabei sein - P3E-Satellit in den Orbit

AMSAT-Phase 3E - kurz P3E - wird der neue Satellit, der für Funkamateure stabile Verbindungen von Kontinent zu Kontinent bietet. Er ist mit seinen Transpondern für 145, 435, 1268 und 2400 MHz Nachfolger von AO-10, AO-13 und AO-40. P3E entsteht derzeit unter Leitung der AMSAT-Deutschland in einem internationalen Team, darunter diverse Gruppen aus Europa, der AMSATNA (USA/Kanada) und AMSATUK (Großbritannien).

Mit einem eigenen Triebwerk erreicht P3E seine endgültige Umlaufbahn mit einer Bahnhöhe von ca. 35.000 km. Von dort werden mehrstündige Funkkontakte über Entfernungen bis zu 16.000 km auf der Erde möglich. Durch seine langsame Bewegung müssen die Antennen nicht permanent nachgeführt werden. P3E wird wieder Funkbetrieb unabhängig von den Ausbreitungsschwankungen der Kurzwellen bieten.

Dank einer effizienten Sendertechnologie und eines neuen, softwaredefinierten Transponders werden auch kleinere und tragbare Stationen P3E nutzen können. Durch die Softwaretechnologie sind flexible digitale Übertragungsverfahren realisierbar. Für Mikrowellenexperimente hat P3E zusätzliche Baken und Transponder.

Wir laden Sie ein, mit der Belegung von Pixeln P3E dem Start ein Stück näher zu bringen!

Im Integrationsraum entsteht der P3E-Satellit.

Join in - Put the P3E Satellite into Orbit

Mounting of components into the satellite

AMSAT Phase-3E - abbreviated P3E - is the new satellite that will provide amateur radio operators with stable communications between continents. With transponders for 145, 435, 1268 and 2400 MHz, it is the successor to AO-10, AO-13 and AO-40. Under direction of AMSAT Germany, P3E is currently being built by an international team, including various groups from Europe, AMSATNA and AMSATUK.

Using its own thruster, P3E will reach its final orbit at an apogee of nearly 35,000 km. From that altitude, radio contacts will be possible on Earth for many hours at a time over distances of up to 16,000 km. Due to its relatively slow movement, antennas will not need to track the satellite constantly. P3E will once again provide radio operation independent of the variable propagation of short waves.

Thanks to efficient transmitter technology and new software-controlled transponders, even small or portable stations can make use of P3E. Additionally the software will support flexible digital transmission protocols. As well, P3E has additional beacons and transponders for microwave experiments.

We encourage you to support the launch of P3E by reserving your pixels today!



Build This Crossboom For Your Cheap and Easy Satellite Antennas

by Richard F. Crow, N2SPI, n2spi@amsat.org.

Author's Note: This is the final article in a series of three articles aimed at providing non-satellite hams, and others, an easy path to acquiring the antennas and information they need to work their first satellite. The first article in the series is "Build this Cheap and Easy Satellite Downlink Antenna" which was originally published in the July/August 2006 AMSAT Journal. The second is "Build this Cheap and Easy Satellite Uplink Antenna" originally published in the September/October 2006 AMSAT Journal. Please read my Author's Notes at the beginning of these other two articles for additional background on this series.

Introduction

As promised in my article "Build This Cheap and Easy Uplink Antenna", here are the plans for a crossboom to hold your uplink and downlink antennas. "Build This Cheap and Easy Uplink Antenna" is one of two companion articles to this one. The other is "Build This Cheap and Easy Downlink Antenna". Read the other two articles first, and build your antennas, before you read this one. If you can't find the other articles, e-mail me.

If you've already built your uplink and downlink antennas, as suggested above, you already understand the need for this crossboom. The design goal here was to use the same laminated foam board techniques as in the antennas but end up with a crossboom, which would be reasonably sturdy. It took a while, but I finally came up a suitable design. The general idea will be to laminate seven foam board strips together to produce a 40 inch long foam board "2x4" which we'll use to make a 3 foot antenna crossboom. Then, we'll attach the crossboom to an inexpensive, lightweight camera tripod. The resulting crossboom and tripod arrangement is surprisingly functional and robust. See Photo 1.

Step-by-Step Instructions

- 1) Read these instruction all the way through to get an idea of what's involved.
- 2) Referring to the list of materials in Table 1, acquire the necessary materials.
- 3) Referring to the list of tools in Table 2, make sure you have the necessary tools or suitable substitutes. If you use a 4-foot carpenter's level, position the

smaller-width side of the level against the foam board when using it as a straight edge. Refer to the uplink and downlink antenna articles for additional tool comments.

In the next 7 steps, make seven 3-1/2 inch by 40-inch foam board strips.

- 4) Position the foam board so a 40-inch edge faces you. Place the two pine boards under the foam board so it is elevated and lies flat and steady.
- 5) Adjust the combination square so 3-1/2 inches of the rule is sticking out of the attached head.
- 6) Then, place the head of the combination square against the 40-inch edge and, with the rule lying flat against the foam

a cutting board. Place the second pine board so the foam board lies flat and steady.

- 9) Be sure the X-Acto knife has a fresh, sharp blade. Now, carefully and patiently (take your time), trace along the line with the tip of the X-Acto knife. At first, just penetrate the surface paper. Repeat, cutting a little deeper each time, and as you can, gently bend back the foam board to expose the cut. Finally, cut through to make a foam board strip hereafter called a "strip". This general cutting procedure is hereafter called "using previous cutting methods".
- 10) Repeat steps 4 through 9 to produce six more 3-1/2 inch by 40-inch foam board strips for a total of seven strips.



Photo 1: The N2SPI Crossboom.

board, make two pencil marks, one 3-1/2 inches up the left side and one 3-1/2 inches up the right side from the edge.

- 7) Using the 4-foot level, or other 48-inch straight edge, draw a 40-inch line between the two marks. The general measuring procedure described in steps 4 through 7 is hereafter called "using previous measuring and marking methods".
- 8) Now, place the first pine board under the line on the foam board so as to act as

In the next 6 steps, locate and mark the center point for circles to be drawn at each end of each strip.

- 11) Adjust the combination square so 1-3/4 inches of the rule is sticking out of the head.
- 12) Then take one of the foam board strips, and using previous measuring and marking methods, place a first mark 1-3/4 inches in from left edge, which is also centered between the top and bottom edges. See Photo 2.



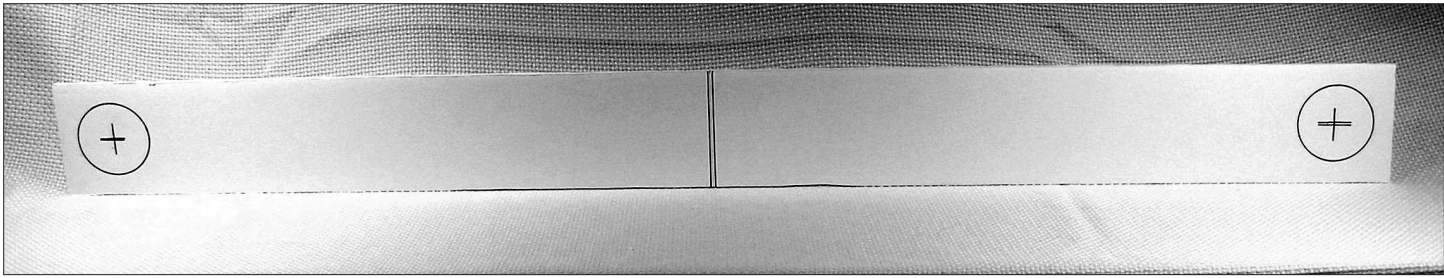


Photo 2: A strip marked up to show the two sets of marks for locating the centers of the two circles (holes) and a pair of lines in the center used to make the 3/16 inch wide slot.

13) Then make a second mark 1-3/4 inches down from the top edge, which crosses the first mark. If the two marks don't cross, extend the first mark.

14) And finally, make a third mark which is 1-3/4 inches up from the bottom edge, which also crosses the first mark. The idea here is to make a set of marks which will locate the center point of a circle that is 1-3/4 inches in from the left edge and centered between the top and bottom edges. Note that if the strip is exactly 3-1/2 inches wide, the second and third marks, measured from the top and bottom edges, will overlap. Otherwise, the middle of the space between the two resulting marks will indicate the exact center between top and bottom edges.

15) Using a procedure similar to that in steps 12 through 14 above, make a second set of marks which is 1-3/4 inches in from the right edge of the strip and is centered between the top and bottom edges. See Photo 2.

16) Repeat steps 12 and 15 until all seven strips are marked the same way. These marks are hereafter called "center marks".

In the next 4 steps, draw two 2-1/4 inch diameter circles at each end of five strips.

17) Adjust the compass to draw a 2-1/4 inch diameter circle.

18) Pick one of the strips. Using the center marks at the left end for the circle center, use the compass to draw a 2-1/4 inch diameter circle at the left end of the strip. See Photo 2.

19) Using the center marks at the right end, use the compass to draw a 2-1/4 inch circle at the right end of the strip.

20) Repeat steps 18 and 19 until a total of five strips have identical sets of circles drawn on them. Set aside the other two strips for making the side panels later.

In the next 3 steps, cut out the circles in each of the five strips from above to make 2-1/4 inch diameter holes. Ultimately, these holes will hold the antennas.

21) Pick one of the five strips worked on above. Using previous cutting methods, and the circle drawn at the left end, cut a 2-1/4 inch diameter hole in the left end of the strip. See Photo 3.

22) Using previous cutting methods, and the circle drawn at the right end, cut a 2-1/4 inch diameter hole in the right end of the strip. When done, there should be two holes, one at each end of the strip. Don't fret too much over cutting these holes super accurately. The finished diameter of these holes is not critical as they are clearance holes for the PVC pipe inserts to be installed in the crossboom later. Nonetheless, try to keep the finished diameter of these holes accurate to +/- 1/8 inch. The critical diameter holes will occur in the two side panels of the crossboom, which will be fabricated later.

23) Repeat steps 21 and 22 until all five strips have identical sets of holes cut into them. These five strips will make the inner core of the crossboom and are hereafter called "inner core strips".

In the next 5 steps, make preparations for a 3/16-inch slot in one of the inner core strips. Later, this slot will accommodate the 1/4-20 bolt which fastens the crossboom to the tripod.

24) Take one of the inner core strips and locate the center of the strip between the left and right edges. To do this, use the tape measure to measure along the bottom edge and make a mark 20 inches in from the left edge. Then measure along the bottom edge and make a mark 20 inches in from the right edge. If the strip is exactly 40 inches long, these two marks should overlap. But if they don't, the middle of the space between the two

resulting marks is the center position of the strip.

25) At this center position, use the combination square to draw a line perpendicular to the bottom edge across the strip from the bottom to the top edge. This line will be called "the center line".

26) Measuring carefully, draw two lines parallel to the center line, one 3/32 inches to the left, and another 3/32 inches to the right. The distance between the two 3/32 inch lines will be 6/32 inches which is the same as 3/16 inches. Later, these two lines will be cut to make a 3/16-inch wide vertical slot in the center of this strip. Double-check this, and if necessary, re-draw the lines that define the 3/16-inch slot to make sure this width is accurate to within +/- 1/32 of an inch. See Photo 2.

27) Flip the strip over and, using the same procedure as above, make a second set of lines for the 3/16-inch slot. When done, both sides of this strip should have lines for cutting the 3/16-inch slot. These lines should line up.

28) Using previous cutting methods, cut halfway along one set of lines to start making the 3/16-inch slot. IMPORTANT: Cut only halfway through the strip.

In the next 9 steps, laminate the first two strips to start forming the inner core of the crossboom.

29) Take the strip with the partial, halfway cuts and place it flat on the work surface with the side with the cuts facing up. IMPORTANT: The side with cuts must face up.

30) From the left end of this strip, lay down a first piece of double-sided tape near the top edge for approximately the first 20 inches stopping just short of the slot. Then, cut the tape neatly with the X-Acto knife. In a similar way, starting



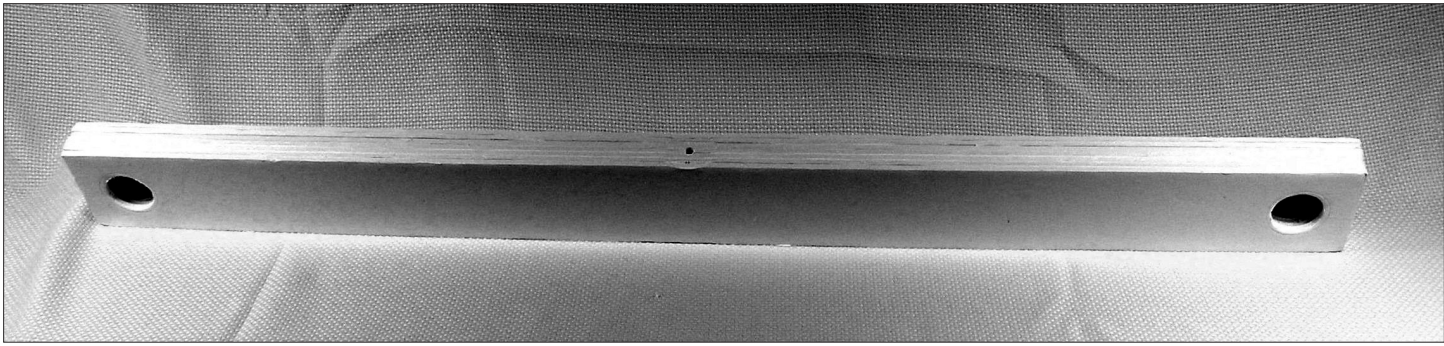


Photo 3: A crossboom with all holes cut and all seven strips laminated together. Note this particular version has side panels with 1 1/2 inch diameter holes, which can hold the antennas directly thereby eliminating the PVC inserts. The crossboom described in the text is exactly the same except that it has larger diameter holes for the PVC inserts.

on the other side of the slot, lay down another piece of double-sided tape along the remaining 20 inches of the top edge. In this step, and the steps that follow, don't let any tape get between the lines that define the slot. If any tape gets into the slot, trim it away before it gets buried in the laminations.

- 31) In a way similar to the step above, lay down two more 20-inch pieces of double-sided tape across the center of the strip. This tape should be centered between the top and bottom edges. For now, lay the tape across the holes at either end of the strip. It will be trimmed out later.
- 32) In a way similar to the step above, lay down two more 20-inch pieces of double-sided tape along the bottom edge of the strip.
- 33) Now, lay down a first strip of double-sided tape, from the top edge to bottom edge, along the left side of the slot, but not in the slot.
- 34) And finally, lay down a second strip of double-sided tape, from the top edge to bottom edge, along the right side of the slot.
- 35) Take a second inner core strip. Check for a warp, if any. If any warping is detected, combine the warp of one strip with and an opposite warp from the other strip, so they cancel out. Then, line up one end and the bottom edge of the new strip with one end and the bottom edge of the strip on the work surface.
- 36) Then, starting at the one end, progressively press the second strip onto the first keeping the bottom edges lined-up.
- 37) Use the X-Acto knife to trim the tape out of the 2 1/4 inch diameter holes.

In the next 3 steps, complete the 3/16-inch wide slot.

- 38) Flip laminated strip assembly over to gain access to the lines for the 3/16-inch slot, which have not yet been cut.
- 39) Finish cutting the other half of the 3/16-inch slot being careful not to nick the uncut strip, the strip without a slot.
- 40) Remove the foam board material in the slot to complete the fabrication of the slot. Note that the strip with the 3/16-inch slot will be the center strip within all the strips laminated together to make the crossboom. Be sure to check and make sure this strip will end up at the center of the crossboom as each additional strip is added.

In the next 5 steps, laminate an inner core strip to the other side of the laminated strip assembly with the slot.

- 41) Take the current laminated strip assembly and place it flat on the work surface with the 3/16-inch slot facing up. IMPORTANT: The 3/16-inch slot must be facing up.
- 42) Using the procedure in steps 30 through 34 to lay down three rows of double-sided tape across the laminated strip assembly plus two more strips of tape on either side of the slot. Again, don't let any tape get into the slot.
- 43) Get another inner core strip. Check for a warp and, if any, cancel it out as explained above. Line up the one end and the bottom edge of the new strip with one end and the bottom edge of the strip assembly lying on the work surface.
- 44) Then, starting at the one end, progressively press the new strip onto the laminated assembly keeping the bottom edges lined-up.

- 45) Use the X-Acto knife to trim the tape out of the holes. When done you should have the three strips laminated together with the slotted strip in the center.

In the next 7 steps, laminate the remaining inner core strips to the inner core assembly.

- 46) Take the current laminated strip assembly and place it flat on the work surface.
- 47) Using a procedure similar to steps 30 through 32 to lay down three rows of double-sided tape across the laminated assembly. No need to worry about the slot anymore. The double-sided tape should now go all the way across the strip, from the left edge to the right edge.
- 48) Get another inner core strip. Check for a warp and, if any, cancel it out. Line up the one end and the bottom edge of the new strip with one end and the bottom edge of the laminated assembly.
- 49) Then, starting at the one end, progressively press the second strip onto the laminated assembly keeping the bottom edges lined-up.
- 50) Use the X-Acto knife to trim the tape out of the holes.
- 51) To prepare for laminating the last remaining inner core strip to other side of the assembly, flip the laminated strip assembly over.
- 52) Repeat steps 46 through 51 to laminate the last inner core strip to the laminated strip assembly. When done you should have the five inner core strips laminated together with the slotted strip in the center. This completes the fabrication of the inner core of the crossboom. The general procedure in steps 46 through 51 in hereafter called " using previous

laminating methods”.

In the next 4 steps, make the holes in the remaining two strips, which will become the side panels for the crossboom.

- 53) Adjust the compass to draw a 1-7/8 inch diameter circle.
- 54) Pick one of the remaining strips, and using the marks made previously for the center; draw two 1-7/8 inch diameter circles, one at each end of the strip.
- 55) Using previous cutting methods, and the circles drawn in the step above, cut two holes, one in each end of the strip. Do try to draw and cut these holes accurately, say within +/- 1/32 of an inch. With careful workmanship, it is these holes, which will hold the PVC pipe inserts snugly.
- 56) Repeat steps 54 and 55 to draw and cut two 1-7/8 inch diameter holes in the other, remaining side panel strip.

In the next 3 steps, laminate the side panels to the inner core of the crossboom.

- 57) Using previous laminating methods laminate one of the side panels to one side of the inner core of the crossboom. Be sure to check for warping in the strips and use the procedures above to cancel it out.
- 58) Flip the current laminated strip assembly over to insure that the strip with the slot will remain at the center.
- 59) Then, using previous laminating methods, laminate the other side panel to the other side of the inner core. Again, be sure to check for warping. When done, the crossboom should be seven laminated strips wide with the slotted strip in the center. This completes the laminating of strips to form the crossboom.

In the next 8 steps, cut two 3-inch long PVC pipe inserts for the holes at each end of the crossboom.

- 60) If the length of PVC pipe you have is 5 or 10 feet, use your saw to hack off a 1-foot section, or so, which will be easier to work with. Make sure the 1-foot section includes one of the factory cut pipe ends.
- 61) Adjust the combination square so 3 inches of the rule is sticking out of the attached head.
- 62) From the factory cut end of the pipe, use the combination square to measure in 3

inches and make a mark.

- 63) Rotate the pipe about 1/8 inch and use the combination square to, again, measure in 3 inches and make a mark.
- 64) Repeat the step above until there are many marks at the 3-inch point all the way around the pipe.
- 65) Using the miter box and saw, cut the pipe at the 3-inch point keeping an eye on your marks as you cut. Hold the pipe firmly in the miter box as you cut. Even better, use suitable clamps to clamp the pipe in miter box, if you have them. If your cut isn't following the marks exactly, make adjustments in how you're ever-so-slightly tilting the saw. Don't "muscle" the saw. Your job is to guide it accurately back and forth. Let the weight of the saw do the cutting.
- 66) Use the flat mill file to smooth and bevel the rough edges, both inside and outside the pipe, produced by the saw. It's easier to smooth the inside edges of the pipe with a round file, if you have one. But with a little patience you can smooth the inside edges with a flat file too.
- 67) Repeat steps 60 through 66 to cut a second 3 inch PVC pipe insert using a 1 foot section of pipe which includes the factory cut end from the other end of the original pipe. If your PVC pipe doesn't have factory cut ends, do the best job you can making nice, square, perpendicular cuts. Note that you might be able to avoid doing steps 60 through 67, as well as purchasing the tools to cut the pipe, if you can find a store to buy the pipe from which will carefully cut the 3 inch lengths of pipe for you.

In the next 6 steps, install the PVC pipe inserts into the crossboom and cement them in place.

- 68) Adjust the combination square so 5/8 of an inch of the rule is sticking out of the attached head.
- 69) Take one of the PVC pipe inserts and, using the combination square, make two marks, one 5/8 inches in from one end of the insert, and another 5/8 inches in from the other end. These two marks will be used to center the insert in the crossboom.
- 70) Then, carefully insert the 3 inch PVC pipe into one of the holes at either end of the cross boom. Twist the pipe as you insert it, if that helps. The fit between the

PVC pipe and the crossboom should be tight. If not, try wrapping 2-inch wide "Scotch" type clear packing tape around the center of the PVC pipe until it fits tightly into the crossboom. See Photo 1.

- 71) Using the marks made above, center the pipe insert in the crossboom.
- 72) Then, place holt-melt glue around the PVC insert, on both sides of the crossboom, to cement it in place.
- 73) Repeat steps 69 through 72 to insert, center, and cement the other PVC pipe insert into the other hole in the crossboom.

In the next 6 steps, remove the rubber pad from the tripod's camera mount platform.

- 74) Place the crossboom assembly aside for now and get the camera tripod.
- 75) Locate the removable camera mount platform in the tripod. Install the camera mount platform back into the tripod, if it's not there already. Use the tripod as a work holder as you remove the rubber pad from it. If you have a bench vise, or some other work holder you'd prefer, then use that.
- 76) Gently use the 1/4-inch wood chisel to slowly and carefully pry pieces of the rubber pad out of the camera mount platform.
- 77) When enough rubber has been pried away, remove the 1/4-20 camera-mounting stud and all other metal parts in the camera mount platform.
- 78) When most of the rubber is gone, I use the tip of the chisel as a scraper to clean away the last few rubber remnants.

In the next 6 steps, install the crossboom on the camera tripod.

- 79) When all the rubber is gone, remove the camera mount platform from the tripod.
- 80) Insert the 1/4-20 by 4 inch long bolt through the hole in the camera mount platform that was formerly used by the 1/4-20 camera mount stud which came with the platform.
- 81) With the 1/4-20 bolt sticking out of the camera mount platform, stick the end of the bolt through the hole (3/16 inch slot) in the center of the crossboom. Twist the bolt, if it helps, while working it through the center of the crossboom.
- 82) Once the 1/4-20 by 4 inch bolt is through the crossboom, place the 1/4 by 1 1/2



inch fender washer over the top of the bolt.

83) Then screw the 1/4-20 wing nut (or hex nut) onto the 1/4-20 bolt. Tighten gently.

84) Place the tripod on a level surface or otherwise level-it-up. Adjust the tripod so the crossboom is in the 90-degree elevation position. This is the position where a raindrop, or vertical rod, will pass through the center of the PVC pipe inserts without touching any surfaces. Use the level to check that the cross boom is level. If you don't have a level then "eyeball-it".

85) Now, tighten the nut modestly, enough to hold the cross boom in place, but not so much as to crush the foam board destructively.

86) If the 1/4-20 bolt alone does not adequately hold the crossboom in place on the camera mount, then here is something to try: Remove the crossboom from the camera mount, fill the scraped out camera mount platform with quick set epoxy glue, re-assemble by repeating steps 80 through 85, and wait for the glue to set. This completes the fabrication and mounting of the crossboom.

And finally, test your new satellite antenna crossboom.

87) Insert the coax connector and coax from your Cheap and Easy Satellite Downlink Antenna through the PVC pipe insert at one end of the crossboom. See Photo 4.

88) Then, insert the handle of your downlink antenna into the PVC pipe insert at this end of the crossboom. The PVC insert should hold your antenna firmly while, at the same time, allowing you to rotate

it freely around its boom axis. If the fit is tight, you may have to rotate your antenna back and forth a few times to wear down the handle a bit and free it up. If the fit is loose, try wrapping 2-inch wide "Scotch" type clear packing tape around the antenna's handle to increase its size.

89) Insert the connector, coax, and handle of your Cheap and Easy Satellite Uplink Antenna into the PVC pipe insert at the other end of the crossboom.

90) Adjust the tripod's azimuth and elevation adjustments so they're tight enough such that the antennas hold their heading, but not so tight that you can't change the antenna's position with a modest push on the crossboom or the tripod's pan head handle. When you're working FM LEOs, you won't have time to repeatedly loosen and tighten the tripod's settings. One tightness setting for each axis of rotation will have to serve from the beginning to end of a satellite pass.

91) Connect the downlink antenna's coaxial cable to your downlink receiver system.

92) Connect the uplink antenna's coaxial cable to your uplink transmitter system.

93) Then, point the antennas in the direction of the satellite and work it as described in previous write-ups for the uplink and downlink antennas.

94) Along the way, pick up some 5-pound ankle weights like those that aerobic exercisers use. If it is windy, wrap one or more of these weights around the legs of the tripod to keep it from blowing over.

95) Being a load bearing structure made out of foam and paper, this crossboom may tend to sag slightly if it's left setup and holding the antennas for extended periods, such as a couple of weeks or more. If this happens, turn it over so it bows upward and leave it this way until it sags downward again.

96) If you don't want to leave the crossboom and antennas setup for extended periods, the antennas may be removed and stored on a wall using hooks or pegs. Also, the antennas can be suspended from the ceiling on hooks provided they are high enough overhead to be out of the way. As for me, I just shove the antennas between books on top of a tall bookcase and the ceiling.

97) In you want to add an elevation indicator to your crossboom, see "www.tiltmeter.com", for example. Sometimes I use the model #45 tiltmeter (\$29 at www.tiltmeter.com). I'll leave it to your ingenuity to devise a method for attaching it. Having an elevation indicator helps greatly in accurately pointing the antennas. The strength of the satellite's downlink signal varies so much that it's tough to accurately aim the antennas on a consistent basis by waiving them around to find maximum signal. I have noticeably better success when I know the elevation is correct and all I have to do is guesstimate the azimuth. To accomplish this, I bring with me a minute-by-minute printout of elevation and azimuth headings for the satellite which I get beforehand from my tracking program. The other part of this setup is a Timex 1440 Sports Radio Controlled (atomic) dual-time wristwatch (\$20 at www.campmor.com, Campmor No. 87244-P or 87245-P). I also have a miniature clipboard, which I attach to my wrist next to my wristwatch, and so it can hold the az/el printout. I fabricated the clipboard out of sheet of Lucite plastic (from Lowe's, Home Depot, etc.).

In Conclusion...

If you need assistance building or using this satellite antennas crossboom, or have other questions or comments, contact me at: n2spi@amsat.org. Please put the phrase "Antenna Crossboom, v2.0" somewhere on the e-mail subject line. ☺



Photo 4: Crossboom and tripod with uplink and downlink antennas ready for action.

Table 1: List of Materials			
Quantity Used	Material Description *	ExampleSource	Example Source Item No. **
1	"Elmer's" 30 inch x 40 inch Foam Board	Staples	245563
720"	1/2" wide "Scotch 665" Double Sided Tape	Staples	130500
1	Camera Tripod	Wal-Mart	000659244
1	1/4-20 x 4" Machine Bolt or Screw		
1	1/4"x 1 1/2" Fender Washer		
1	1/4-20 Wing Nut (Hex Nut))		
2	3" Lengths of 1 1/2" Schedule 40 PVC Pipe		
* Name in "quotes" is the brand of product I used. "Equivalents" should be OK.			
** Some "Example Item No.(s)" come packaged in higher quantities than "Qty Used".			

Table 2: List of Tools		
Tool Description	Example Source	Example Source Item Number
12" or 16" Combination Square	Sears	00939681000
Small Tape Measure	Sears	00939697000
4 Foot Carpenters Level (or other 48"straight edge)	Sears	00939813000
1/4" Wood Chisel	Sears	00936850000
Miter Box with Saw	Sears	00936317000
Mill File	Sears	00931300000
"X-Acto" Knife with #11 Blade	Staples	506998
"X-Acto" #11 Blade Refills	Staples	428300
Compass (for drawing circles)	Staples	371130
Hot Melt Glue Gun with Glue Stick	Staples	508701
48" long 1 inch Pine Boards, Qty=2	Lumberyard	
Sharpened Pencil		





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